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THE

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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Food from Forests

Although agricultural science is making an impressive contribution to our food crop production, both by the use of fertilizers and by control of pests and diseases, the climate of much of East Africa will always place severe restrictions on both the amount and the reliability of the total food output. Dr. Egon Glesinger, chief of the Forest Products Division of the United Nations Food and Agriculture Organization, has given in his book *The Coming Age of Wood* some details of the practical possibilities of cellulose as a source of human and animal food, which are therefore highly interesting to these territories.

The urgency of wartime shortages caused German chemists to exploit the earlier achievement of the Nobel prizewinner, Dr. Friederich Bergius, who first obtained sugars from cellulose by acid hydrolysis. The treatment of cereal straw with acid or alkali for feeding directly to cattle was proved to be a practical possibility and the alkali method was later introduced by the British Ministry of Agriculture on a commercial farm scale. Treatment of straw with caustic soda is an unpleasant process in practice and appears to have made little popular progress. However, the German chemists simplified the Bergius acid hydrolysis to the boiling of wood-chips with dilute sulphuric acid. The resulting complex syrup of sugars and by-products is too difficult to separate into its useful components, but it makes an excellent food medium for yeast plants. Under anaerobic conditions, the product is alcohol, which the Germans required for aircraft fuel and for manufacturing processes. If the common yeast *torula utilis* is grown with a free air supply, the yeast itself becomes the edible product of the reaction. The food value of yeasts from the brewer's vats has, of course, been known for some decades, but the brewer feeds his yeast on barley. Dr. Glesinger stresses the vast potential importance of food yeasts grown on hydrolysed wood, or rather on plant cellulose, many kinds of which are suitable.

When the nitrogen supply is increased by bubbling ammonia gas and a free air stream through the solution, a few pounds of yeast can produce a ton of dry matter a day. This dried yeast contains nearly 50 per cent of protein and is rich in the B group of vitamins. In this connexion, the probable manufacture of ammonia by fixation of atmospheric nitrogen with the electrical power from the Owen Falls may well prove to be of the greatest importance. Yeast is already in large-scale production in Jamaica, where a British factory, using the waste-products of the sugar industry, is producing 5 tons of food yeast a day.

The product is a dry food powder which may be used as a flour. Fortunately the possibilities of yeast, even when grown from cereals, or molasses, have received a lot of attention from research workers on nutritional problems. A British chemist, A. C. Thaysen, first showed that yeast can be made to propagate sexually by spores, and can therefore be crossbred to select desirable characteristics. Two American research workers, Dr. and Mrs. Carl Lindegren, developed this selection during the war, and produced hundreds of hybrid varieties. Among these were yeasts with high protein and vitamin content and with "meaty". "nutty" and "celery" flavours. Under the conditions in the vats, reproduction is by simple binary fission, so that the selected characteristics are reproduced on a vast scale. Dr. Glesinger may be a little optimistic about this, since the management of brewers' vats is recognized as requiring constant vigilance, and on a large scale the production of yeasts with acceptable flavours may be just as difficult.

It is probable that while skill is being developed in the large-scale production of yeasts from wood, the greater part of the products will be used at first as cattle feed. The value of brewer's yeast as cattle feed has long been accepted and very large quantities are used.

The importance of Dr. Glesinger's argument for East Africa lies in the relatively small proportion of our total area which enjoys a high and reliable rainfall. In these favoured areas trees are by far the most productive of crops. The commerical value of East Africa's forests is already high, and is increasing rapidly, but there is a great deal of unproductive vegetation and of forest prunings, tops, bark and other wastes which might be most effectively utilized for yeast production.

Research on local production of food yeast was begun in Nairobi by the E.A.I.R.B. during the war, and had made sufficient progress for the planning of a pilot factory. This project was postponed because of plans to build a similar plant in South Africa, and does not appear to have been revived.

At present no effective economical use is made of sawdust, the most convenient of wood products for chemical processing. Similarly the large mill production of coffee hullings in Nairobi is burned in open dumps, since no economic use for this material has yet been discovered.

East African plantation agriculture is still comparatively young, and the integration of by-products with local industry is only beginning. In fact, the waste products of coffee and sisal are at present a serious problem in water pollution. Practical use of the cattle-food value of Kenya coffee pulp, of which several thousand tons are at present wasted annually, is in the exploratory stages at the Coffee Research Station at Ruiru. When dried and ground, this pulp appears to have a feeding value of about four-fifths of maize meal. The chemical possibilities of sisal waste products are similarly almost unexploited at present. The late William Politzer, whose tragic death in a climbing accident was a great loss to East Africa, showed in the *E.A.A.J.* of July, 1949 (Vol. XV, No. I, p. 12) that valuable waxes, at present bought only for dollars, can be extracted from sisal waste. A commercial enterprise has indeed begun to prepare sisal by-products on a small scale in Kenya. The paper on page 21 shows that a new field of very great promise is being opened through combined medical and chemical research into the extraction from sisal waste of the raw materials for the synthesis of cortisone, the drug used in the treatment of arthritis.

East Africa has little enough of energy resources in coal, oil or water power, but a generous and reliable supply of sunshine. The results of world-wide scientific research applied through the powerful methods of modern chemical engineering to the products of photosynthesis in forest and plantation will increasingly turn this sunshine into real wealth.

H. C. P.

BOOK REVIEW

FOREST ENGINEERING—ROADS AND BRIDGES, by J. L. Harrison, (1951). Oliver and Boyd, Edinburgh. pp. i-xv, 1-366, plates 9, diagrams 38. Sh. 30.

This excellent book has two aims, to be a textbook for the university forestry student, and to provide serving Forest Officers with a reference book which will help them in their own particular problems. Few are better qualified to compile such a book than the author, for Mr. Harrison is a trained Forest Officer, a trained engineer, and in addition has had forest engineering training in the U.S.A. He does not attempt to cover the whole of forest engineering, but wisely confines himself to roads and bridges.

Forest roads and bridges must necessarily by their usual remoteness from civilization, and for reasons of economy of capital cost and maintenance fall short of normal civil engineering standards. They also usually must be built as far as possible of materials available near the site. Hence normal civil engineering textbooks on the subject do not meet the particular needs of forest officers. All these points have been borne in mind in this book. The road constructions dealt with are designed on standards that would make forestry operations economically possible. The calculations with regard to bridges and other timber structures have purposely been kept as simple as possible, and with so much data now available for tropical timbers not normally used in construction, suitable sizes of timbers for bridges in Commonwealth countries can be worked out. Many representative examples are worked out in detail. In the section on bridges there are chapters on River Training Works, and on Timber Joints, subjects so often omitted.

The book is well produced with clear print and is illustrated by nine excellent plates of photographs and by 38 diagrams. The author is to be congratulated on a simple and useful exposition of his subject, and it is to be hoped he will follow the present work with similar ones on the other engineering subjects which concern the Forest Officer.

Although the book is written primarily for Forest Officers and forest students it is exactly what is required by farmers and others who are faced with carrying out rough but serviceable up-country engineering, and to them it can be thoroughly recommended.

A.L.G.

MINERAL DEFICIENCIES IN FARM LIVESTOCK

By M. H. French, East African Agriculture and Forestry Research Organization

(*Received for publication on 7th July, 1952*)

Although references to the feeding of "salts" to domesticated animals can be traced back to the time of Plutarch and although both Pliny and Virgil extolled the value of salt for milk production, detailed studies of the need for minerals by farm animals did not commence until this century. In fact, 50 years ago rations were judged by their ability to provide protein and energy and it was not until the importance of the "accessory food factors" or vitamins had been realized, and evidence obtained of the spectacular recoveries which could be produced by feeding vitamins to deficient animals, that biochemists received the necessary stimulus to search for other "deficiency diseases". This work quickly demonstrated that mineral deficiencies imposed a heavy annual drain on the economics of livestock production in general and that certain specific mineral supplements could cure serious pathological conditions.

Normal chemical analyses showed that certain elements were present in the soil, the herbage and the bodies of the grazing animals. More delicate spectrographic analytical methods added to this list certain other elements which are present in such small amounts that, with the older methods of analyses, it was possible to record their existence only as a "trace". It has now been found that some of these "trace" elements are essential to health and production even though they are present in minute amounts.

As work on mineral metabolism progressed it was found that, of the many elements normally occurring in the food and bodies of animals, only a limited number are essential for health and productivity and, of these essential elements, the ones most likely to be in deficient supply are calcium, phosphorus, sodium, chlorine, iodine, iron, copper and cobalt. According to the conditions of feeding and the type of livestock, a deficiency of any essential element may be a limiting nutritional factor.

Experience has shown that it is not necessarily those elements required in the greatest amounts by the animal body or its products which are most likely to be inadequate in the food. Quite often, in fact, deficiencies and serious pathological conditions can occur when the minute requirements for trace elements are not adequately supplied. It is not the total quantity of an element which is important but the difference between the animal's requirements and the amount available from its food. Under natural conditions animals can obtain their mineral requirements from their food but this may be impossible when—

(*a*) highly productive stock are fed poor or unbalanced rations,

(*b*) the breed of animal is improved genetically without a corresponding improvement in its environment,

(*c*) the soil, and consequently the herbage, is deficient in an element essential for health and continued production, and

(*d*) animals of high productivity are intensively managed and fed largely on supplementary foods.

Under such conditions, mineral deficiencies may occur which may retard growth and reproductive rates, interfere with lactation or egg production and cause skeletal abnormalities and other pathological conditions which can end fatally.

It is extremely difficult to present a concise, comprehensive and chronological account of the study of mineral deficiencies in farm livestock and such a treatment has not been attempted. Instead, attention has been directed to likely East African deficiencies.

Sodium and Chlorine

These elements are widely distributed throughout the plant and animal kingdoms and also occur naturally as ordinary salt. They are found chiefly in the fluids and soft tissues of the body and the animal has no means of storing appreciable quantities. Amounts in excess of requirements can be eliminated by the kidneys although excessive intakes may lead to poisoning in certain species and to oedematous conditions in others. When the intake of these elements is low, the body attempts to conserve them by reducing the rate of excretion. When, as in a high yielding cow, other body secretions are drawing on the body's supply of these elements, a point is reached when the kidneys can no longer reduce

urinary excretion to a level which will allow a balance between intake and output.

It is probably because of this that very early references are to be found on the value of salt for milk production, and that the feeding of salt to animals became a traditional practice in civilized countries. The effects of salt deficiency in milking cows were investigated in Wisconsin early this century and it was found that cows deprived of salt for 2-3 weeks developed an early craving for it but that a longer period, in some cases up to a year, was necessary before health was affected. Eventually, however, salt deficiency caused a loss of appetite, an unthrifty condition, a drop in milk production and a loss in weight. The symptoms occurred earlier in the heavier yielding cows and were most frequent at calving or at the height of the lactation.

Other experiments have demonstrated the need for feeding salt to maintain optimum growth rates in several classes of animals, for full egg production and to maintain appetite for economical rates of fattening. In fact, salt should be fed to all classes of livestock at the rate of 0.5 per cent of the dry matter in the total daily ration because, apart from its nutritional value, salt acts as a condiment for stimulating appetite and for rendering other foods more palatable.

In hot areas, particularly for animals which perspire, salt becomes of even greater importance than in temperate regions. In East Africa, most farmers feed salt and advanced symptoms of salt deficiency are not encountered, but this does not mean that the majority of farmers are feeding the optimum amount of salt. The only reference to pathological conditions resulting from salt shortages under conditions similar to those of East Africa are the observations of Peck. He records the beneficial effects of salt in preventing Gudan (an arthritis) in Somaliland camels. He also reports that salt will prevent the camel disease "Dalehan"—a cutaneous necrosis characterized by local painful swellings which can develop into open enlarging skin sores. Such salt-deficient animals become lethargic, their coats become dry and dull, their milk yields are reduced and accidental wounds or sores are difficult to heal.

Lime and Phosphate

These minerals are considered together because of the intimate association of calcium and phosphorus in the bones. Bone growth and metabolism involve both elements and a deficiency of either interferes with the assimilation of the other. Over 99 per cent of the body calcium and from 80 to 85 per cent of the body phosphorus is located in the skeleton. Lack of either or both of these elements in the rations of young or growing animals interferes with the deposition of mineral matter in the developing bones and, if continued, causes the bones to be so weak that they cannot support body weight without becoming distorted. It has also been found that a serious disproportion in the ratio of calcium to phosphorus will also lead to bone abnormalities even when the absolute amounts of the two elements are not deficient. So long as the ratio of calcium to phosphorus is within the range between 1 to 2 and 2 to 1 both elements can be utilized efficiently but, outside this range, excess of one reduces the utilization of the other.

Not only must both elements be present in certain minimal amounts and in the correct proportions but, for normal bone development, an adequate supply of Vitamin D must also be available. Since Vitamin D can be formed in the body when an animal is exposed to sunlight, the problem of adequate Vitamin D supplies is considerably reduced in East Africa and needs to be watched only for those animals (such as pigs and poultry) which spend a large proportion of their time indoors.

The supply of adequate amounts of calcium and phosphorus is not only necessary to prevent rickets and other pathological conditions in the bones of young animals but is also necessary in adult life after the skeleton has ceased growing. Whilst the proper calcification of bones is important for giving structural rigidity to the skeleton, bones also serve as reserves of these minerals, which can be drawn upon by the animal when the food supply is below the body needs. Milk contains both calcium and phosphorus, and so heavy yielding cows are often secreting, in their milk, quantities of these elements in excess of those provided in their ration. Under these conditions, the deficiencies are temporarily met from the bone deposits. In the same way, heavy laying poultry draw upon their bones to meet the sudden large demand for lime to form egg shells. Unfortunately, when bone reserves are mobilized to meet a deficiency of either calcium or phosphorus, both elements are withdrawn and the unwanted element is excreted unused.

With high levels of production it is not possible to ensure that the consumption of these minerals always exceeds the output from the animal. If, however, the consumption over a period equals or exceeds the output over the same period, no serious damage occurs because during periods of low output the body is able to replace the bone reserves which were mobilized and used during periods of peak production. If the food supply does not meet production needs and the body is given no opportunity to replenish depleted bone reserves, the animal reduces its production in an attempt to conserve its body supplies. If the food supply of these elements is so low that the animal cannot make good its losses, serious pathological conditions develop which may lead to death.

Before considering specific calcium or phosphorus deficiencies, it is convenient to review the amounts of these minerals in the normal farm foods. The cereal grains contain little calcium but fairly large amounts of phosphorus whilst cereal by-products are rich in phosphorus and low in calcium. Oilcakes are rich in phosphorus and supply medium quantities of lime, grass and grazings usually contain fair quantities of both elements, although shortage of phosphates is sometimes encountered, whilst leguminous forage is rich in lime. On general grounds it would be expected, therefore, that herbivora feeding on herbage and fodders will be more likely to suffer from phosphate deficiency than from shortage of lime, whilst pigs and poultry, which feed largely on grains and their by-products, will be more likely to suffer from shortages of lime.

Phosphorus

Shortages of phosphorus in the soil and grazings have been reported from many areas of the earth and deficiency symptoms in grazing animals have been reported from these areas. Cattle are more susceptible than sheep or horses but phosphorus insufficiency may affect all classes of domestic stock. Lack of phosphorus reduces appetite and interferes with the assimilation of other nutrients, causes unthriftiness and loss of weight and retards growth. It interferes with reproduction by affecting the regularity of the heat period and may suppress it completely. The inorganic phosphorus content of the blood is lowered and this leads to skeletal abnormalities, fragile and easily-fractured bones, stiffness and lameness. In severe cases, the appetite becomes depraved and the deficient animals chew bones and other carcass debris and, if the deficiency is not corrected, it may lead to collapse and death. In the less obvious cases, lack of phosphorus reduces the efficiency of production and may be a serious factor affecting the economics of animal industries.

In parts of East Africa, particularly in the dry season, the quantity of phosphorus available to grazing animals is insufficient for high milk production and in other areas is insufficient to maintain normal blood contents in growing, lactating or pregnant Zebu animals. The shortages are, however, not sufficiently great to cause depraved appetites and bone chewing, but are enough to slow down growth and reproductive rates and to reduce milk production.

Experiments carried out by the Rowett Research Institute in 1927-29 indicated that the feeding of mineral supplements to milking cows at Molo increased the milk yield and the birth weights of calves. In fact, after salt, phosphorous supplements are probably the most widely needed minerals for ruminant herbivora in East Africa. This element can be supplied in the form of bone or carcass meal, bone ash or rock phosphates, whilst the feeding of cereal residues helps to correct deficiencies.

Calcium

Calcium deficiency is unlikely to occur in East African ruminants except when cows are subjected to repeated heavy lactations without adequate lime supplements. To maintain high milk yields, cows must either be fed lime or they will draw upon the skeletal reserves of calcium until the bones become fragile and fracture easily. Lack of calcium may cause difficulties at parturition and reduce milk production.

Bone abnormalities which are sometimes encountered in pigs can be prevented by the feeding of lime, whilst shortage of calcium in rations for breeding sows will result in small litters which will grow slowly on the reduced supply of sow's milk. The only way to ensure a sufficiency of calcium to heavy laying birds is to provide lime or oyster shell grit in hoppers so that the birds can help themselves. Lack of lime in poultry rations at first causes weak-shelled eggs which crack very easily. If the shortage is not corrected, the egg yield is reduced and the hens may develop deformed bones.

Horses sometimes suffer from calcium deficiency when they are fed large quantities of cereals and brans. Young horses are more susceptible than adults and among the first symptoms of deficiency are stiffness, lameness, stumbling and a disinclination to move. In more advanced cases, the bones become porotic and soft and later swell. This swelling is particularly noticeable in the head and "Miller's Disease" is sometimes referred to as "big head". These conditions occur when horses receive large percentages of bran in their rations without compensating amounts of lime.

Iron

This element forms only some 0.004 per cent of the body but performs a vital function in transporting oxygen to the tissues. Most normal rations contain a sufficiency and most farm animals supplement the food supply from soil, eaten deliberately or ingested as a contaminant of the food. Lack of iron supplies can cause anaemia but in East Africa this is most likely to occur when suckling piglets are kept exclusively on cement floors. Such an anaemia can be prevented by painting the sow's teats daily with a solution containing 3½ oz. ferrous sulphate and ½ oz. of copper sulphate dissolved in 6 fluid oz. of water to which is then added 6 fluid oz. of molasses.

Copper

Copper deficiency has been reported from many parts of the world as being responsible for wasting or emaciating diseases in cattle and sheep and young horses. The symptoms in young stock are unthriftiness, stiffness, lack of co-ordination of the limbs and failure to grow and often death at an early age. Deficiency in adults is largely responsible for emaciation, unthriftiness, anaemia and a loss of pigment from the hair. In adult sheep shortage of copper causes the wool to become stringy, straight, limp and glassy-looking.

The East African literature contains suggestions that copper deficiency is a likely nutritional factor affecting stock as well as recommendations that further attention might profitably be given to the supplies of this element. One difficulty in the past has been the inability of local investigators using locally available apparatus, to estimate minute amounts of copper with a high degree of accuracy but, now that this difficulty has been removed, more intensive investigations into the copper status of grazings and animals are being carried out or are being planned.

Cobalt

Deficiency of this element is also responsible for wasting and emaciating diseases in several countries. Sheep are more susceptible than cattle but, in both species, the clinical picture is that of chronic starvation, often in the presence of apparently adequate grazings. The symptoms are loss of appetite, emaciation, anaemia, and often death. Milk yields are reduced, in-calf cows abort and are difficult to get in-calf again.

In East Africa, "Nakuruitis" or enzootic marasmus, occurring near Lakes Nakuru and Naivasha, has been identified with cobalt deficiency. Work oxen, milking cows, nursing sheep and weaner lambs are most likely to be affected and the disease may run a slow course or may cause rapid loss of weight ending in death. It can be cured by feeding licks containing cobalt or by moving the stock to unaffected areas. The symptoms are more common after the rains, when grazings are plentiful, and the condition is recognized by Masai herdsmen as "narurasha".

Deficiency can be prevented by the feeding of 0.3 mg. per day to cattle and 0.1 mg. daily to sheep, but deficiencies are unlikely to occur unless the cobalt content of the soils is less than 2 parts per million. The exact role of cobalt in ruminant nutrition has not yet been fully elucidated but recent work suggests that cobalt, in the form of Vitamin B_{12} (anti-pernicious-anaemia factor) is essential to the animal and that other cobalt compounds play an important role in the rumen itself.

Iodine

Although deficiency of iodine is known to cause goitrous conditions in farm animals in certain parts of the world, animal goitre is not believed to occur in East Africa.

Thus, if livestock owners are to take full advantage of the knowledge already available for East African conditions, increased attention should be paid to mineral nutrition.

Summary

The most universal mineral supplement needed by farm animals in East Africa is salt (sodium chloride) which should be fed at the rate of 0.5 per cent of the dry matter of the total ration.

The supply of phosphorus is insufficient in a number of areas (particularly in the dry season) to maintain an optimum level in the

blood of growing or lactating Zebu cattle. The supply from dry season grazings may also be below the requirements of heavy milking imported or grade cows.

Whilst shortage of calcium has not been reported in Zebu stock, it is probable that intensively managed high yielding cows require lime supplements. Lime should always be included in pig and poultry rations and for heavy-laying birds should be provided in separate containers. Lime should also be included in the concentrates fed to horses.

The iron, copper, cobalt group of "trace" elements is probably deficient in certain areas but a full survey of these possible deficiencies has not yet been conducted. In all cases of doubt, or where there is a dry season anaemia, or where there is any suggestion of wasting diseases or stringy wool in adults or inco-ordination, unthriftiness and high mortality rates in young lambs, these minerals should be incorporated in the normal mineral supplement.

General purpose mineral mixtures for ruminants should contain 1½ parts of lime, 1½ parts bone meal and 1 part of salt, whilst for pigs, poultry and horses the lime should be increased to 2 parts to 1 part of bone meal and 1 part of salt.

Where it is desired to feed "trace" elements, 1¼ lb. of a mixture of 10 parts ferrous sulphate, 3 parts copper sulphate and 1 part cobalt sulphate should be mixed with 100 lb. of the general purpose mixture.

BOOK REVIEW

A HANDBOOK ON HIDES AND SKINS, by I. Mann (Revised edition of November, 1951), pp. 103 with 31 photographic plates and two folding sheets of constructional diagrams. Government Printer, Sh. 3/50.

This new and enlarged edition of the Kenya Veterinary Department Handbook is very much more than a guide to field officers. It is a remarkably comprehensive instruction book for all who are concerned with this important industry and its great potential development.

Dr. Mann gives a brief but very clear description of the physiological structure of hides and skins, the objects of tanning and the main processes involved. The damage done by disease and unskilful handling is well illustrated, and the widespread destruction of good leather by excessive and unnecessary branding is emphasized.

Detailed instructions on flaying, drying, washing, fleshing and trimming are illustrated by clear full-page photographs. The frames required for drying are well illustrated, and two large sheets of drawings, folded into the back of the handbook, give details of simple construction of a field abattoir and hide store. Information on storage includes details of insecticide treatments of the hides.

Appendices contain copies of the Kenya legislation governing the trade in hides and skins.

The author is to be congratulated in condensing a remarkable amount of useful information into such a clearly intelligible handbook. It will be widely welcomed by farmers throughout East Africa, as well as by the field officers for whom it was written.

H.C.P.

A FLORA FOR TROPICAL EAST AFRICA

By P. J. Greenway, East African Herbarium

(*Received for publication on 25th March,* 1952)

In the early 1930's the preparation by the staff of the Herbarium of the Royal Botanic Gardens, Kew, of a Flora for Tropical East Africa was mooted. The area to be covered by the flora was Uganda, Kenya, Tanganyika and Zanzibar. However, the project had to be abandoned because money was not forthcoming from the United Kingdom or East African governments and nothing further was done until 1947 when a body of distinguished biologists, under the chairmanship of the late Sir Frank Stockdale, was appointed by the Colonial Research Committee to consider the practicability and desirability of forming a Colonial Biological Survey.

The outcome of the Stockdale recommendations was that assistance should be afforded at once to the Royal Botanic Gardens, Kew, in the preparation of a much-needed Flora of Tropical East Africa, work upon which had commenced before the 1939-45 war. This recommendation was endorsed by the Colonial Research Committee and was accepted by the Secretary of State for the Colonies.

Subsequently two grants were made from Colonial Development and Welfare Research Schemes, one to finance the attachment to the Royal Botanic Gardens, Kew, of additional botanical and ancillary staff to enable the flora to be prepared as rapidly as possible, and the other to meet the cost of erecting a building in the grounds of the Coryndon Museum in which to house the original Herbarium of the Coryndon Museum and the extensive Herbarium of the East African Agricultural Research Institute, Amani, Tanganyika. The building was completed early in 1950; both collections are now being amalgamated in the new building and they will be known as the East African Herbarium.

As staff was assembled at Kew the botanists recommenced work on the flora of tropical East Africa and one of their first tasks was the naming of numerous collections of dried plants that had been received at Kew from East Africa before and during the war. In the course of this work the staff at Kew, working under the Director, Sir Edward Salisbury, C.B.E., D.Sc., F.R.S., with the Keeper of the Herbarium, Dr. W. B. Turrill, F.L.S., and Mr. E. Milne-Redhead, M.A., F.L.S. decided as a preliminary to write the family Ranunculaceae for the proposed Flora of Tropical East Africa.

The Ranunculaceae has now been completed and was published under the authority of the Secretary of State for the Colonies, by the Crown Agents for the Colonies, 4 Millbank, Westminster, London, S.W.1, on 11th February, 1952. It appears as a very slim volume bound in olive green paper covers size 6 in. × 10 in. together with a foreword and preface in a similar binding for the sum of Sh. 3.

The foreword, from the Colonial Office, explains how the Flora came into being. The preface by the two editors, Dr. Turrill and Mr. Milne-Redhead, gives the countries that are covered by the Flora with their areas, a total surface of 682,649 square miles with an altitudinal range from sea level to 19,565 ft. (Mt. Kilimanjaro). The geographical divisions used in the Flora are based on provincial boundaries shown on certain official maps. The appropriate abbreviations used are cited under every species or named intraspecific variant so as to indicate the distribution within the area covered by the Flora. Outline maps together with the details of these divisions are provided and the divisions will be used for the Flora even if political boundaries are changed before it is complete.

It is proposed to quote one to three specimens from every territory in which the species or named intraspecific variant occurs and as far as possible specimens of which there are known duplicates in Great Britain and East Africa are being selected. Altitudinal ranges of a species are given where they can be obtained from the collector's field notes. Synonyms are to be quoted with complete reference in so far as they are the basis of the nomenclature and affect the East African flora. Type specimens are to be quoted whenever possible and abbreviations are used to indicate the herbaria in which the type specimens are or were located and a dagger sign is to be used when the type is missing or has been destroyed through war. Some 26 letter abbreviations are used for bibliographical references comprising most of the books and periodicals that contain information on the plants of East Africa.

The editors conclude their preface by saying "The Flora is to be published family by family as typescripts become ready for printing, irrespective of systematic order. Names of the families are printed on the covers. For those of the angiosperms, the names are alphabetical followed by three columns of figures giving the sequence according to the systems of Bentham and Hooker, Engler and Prantl.

and Hutchinson. This scheme will allow the parts readily to be arranged according to any of these systems or alphabetically if so desired. A key to the families and a general index are to be published at the completion of publication of the Flora".

In the ferns and fern allies there are 22 families, cone bearers four, flowering plants 206 families. The Ranunculaceae, the first family in the flowering plants to be published in the Flora of Tropical East Africa fills 23 pages including an index. It is written by the editors Mr. Milne-Redhead and Dr. Turrill. Seven genera in the family are represented in East Africa, *Clematis* "Old man's beard", *Clematopsis, Thalictrum* "Meadow Rue", *Anemone Knowltonia, Ranunculus* "Buttercup" and *Delphinium* "Larkspur". There are seven species of *Clematis,* two species of *Clematopsis,* four species of *Thalictrum; Anemone* one species covering three varieties, *Ranunculus* nine species and *Delphinium* four species are represented in East Africa. Some of the older taxonomic botanists will be shocked at the modern concept of a species; for instance, *Clematopsis,* in a monograph of the genus published in 1920, contained 15 species, to date five more have been described and of the 20 known species five were recorded from East Africa. In the Flora there are only two, *Clematopsis uhehensis* and *C. scabiosifolia;* the first is a very distinct species having simple leaves, the second has compound leaves with a great range of variation within the species over its geographical area, covering Nigeria to Angola in the west, and from the Anglo-Egyptian Sudan in the north to Portuguese East Africa in the south. Recent workers have divided this aggregate species into seven groups, of which five are recorded in East Africa. Into these groups three species out of the five known disappear.

The authors give a description of the family, followed by a key to the seven genera, then each genus is described in its sequence.

Under each genus there is a key to its species, this key is followed by each species, giving specific name references to the bibliography, the type of the species and the herbarium in which it can be studied.

There is a detailed description of each species followed by the area in East Africa in which it is to be found and the citation of one to three specimens which the authors studied. This is followed by the geographical distribution of the species in Africa and other parts of the world, its habitat and altitudinal range and concludes with synonyms, quoting the type specimens and the herbaria in which they are to be found.

The Flora attempts to steer a middle course, it cannot be described as popular nor as high-brow or highly scientific although it contains technical terms that may be a stumbling-block to the layman. It is well illustrated and this part contains five full-page line drawings in which part or whole of the plant is shown on a page along with analytical drawings of parts of the plant; that of *Delphinium,* for instance, shows a plant, a leaf-blade, inflorescence, flower bud, front sepal, back petal, stamen and pistil. These illustrations should help the layman to find the genus he is seeking. Unfortunately all the genera are not illustrated, as *Clematopsis, Anemone* and *Knowltonia* are not shown, whilst *Ranunculus* has been favoured with two drawings, one of *Ranunculus oreophytus* and all its parts, the other a plate showing a leaf of each of seven species out of the nine described. The drawings are done by two artists, signed D.R.T. and M.R., who are to be congratulated on their delineation, in spite of the preface omitting to say who they are.

Both editors and co-authors are to be congratulated on the first part of the Flora of Tropical East Africa. Further parts of this long-delayed Flora are eagerly awaited although we are warned in the foreword its preparation will take many years. The commencement of the publication of such a long-needed Flora will stimulate the interest not only of the specialist but also of the layman who would like to know something about the many and interesting plants which surround him.

The Flora of Tropical East Africa, the first part, Ranunculaceae, is obtainable from: The Government Printer, P.O. Box 128, Nairobi, the Government Printer, Dar es Salaam, Tanganyika, the Government Printer, Zanzibar, the Uganda Bookshop, P.O. Box 145, Kampala, Uganda, or the Crown Agents for the Colonies, 4, Millbank, London, S.W. 1. The publication is produced and printed by the Whitefriars Press, Ltd., London and Tonbridge, and its price (Sh. 3) cannot be said to be excessive, especially in these days of high costs of printing and paper.

The next part, Oleaceae, the Olive family, now in the press, will be of interest to foresters and those dealing with timber as it is of great economic importance for its woods.

A NEW PRESENTATION OF THE SEASONAL RAINFALL OF EAST AFRICA

By M. W. Walter, East African Meteorological Department

(*Received for publication July*, 1952)

In agriculture as in numerous other spheres, development on a large scale is at present taking place in the East African territories—Kenya, Uganda and Tanganyika. The planning of such schemes and their success depends to a large extent on the seasonal rains. The study of rainfall in East Africa is still in a very early stage. The statistics available are small in number and cover only a short period, but in view of the urgency of the need, it is felt that any new ideas which will lead to a better understanding of the behaviour of the seasonal rains should be put forward now, whatever their limitations.

The distribution of rainfall over a region is normally shown by joining points at which equal totals are received, to form an "isohyetal" map. It will be appreciated that such a map must inevitably contain inaccuracies through lack of information. Figure 1 shows the number of observing stations in each degree square—that is, a square bounded by lines of latitude and longitude one degree apart. Nearly two-thirds of the squares have less than ten gauges each. Vast areas in the Northern Frontier Province of Kenya have no rain gauges at all, and there is also a lack of information from Southern and Central Tanganyika. The settled areas, on the other hand, are comparatively well provided. An Isohyetal map thus gives as accurate a picture of the rainfall of a region as is possible from the network of stations. The closer the stations are together, the truer the presentation. It also brings out sharply the effect of the topography on rainfall.

It is generally considered that the minimum period for the calculation of a reliable average is 35 years, whereas in East Africa it is estimated that only 20 per cent of the stations have records extending beyond 20 years, and about 50 per cent have records for less than 10 years.

It is well known that the distribution in space, as a result of topography, gives an extremely complicated pattern, and when more information becomes available from a closer network of stations the pattern may be expected to become even finer.

The distribution of the rainfall over East Africa in time is also complicated. It has been observed that for all practical purposes, Southern Tanganyika has a single rainy season. Northern Uganda and north-west Kenya tend towards a similar distribution, but at a different time of the year. The regions on or near the Equator, however, experience two rainy seasons a year. The intervening dry period shows considerable local variation in duration and degree of aridity from season to season.

This distribution may be accounted for by the unequal geographical extension of East Africa on either side of the Equator: the northern boundary of Uganda extends to only 5° N. whereas the southern limits of Tanganyika are 12° S.

The explanation of the fact that rain falls in different months of the year at different places in the inter-tropical belt is well known; there is a rain-belt which follows the apparent movement of the overhead sun. If this were the complete explanation, the onset of the rains and the time of heaviest rainfall would depend entirely on latitude; stations on or near the Equator would experience two rainy seasons a year, in April and October. Further away from the Equator the seasons would tend to merge into one, so that near the Southern Tropic there would be a single rainy season in January and near the Northern Tropic there would be a single rainy season in July. But in actual fact the seasonal behaviour of the rains is not so simple.

The purpose of these notes is to study the geographical movement of the rain-belt. The isohyetal method gives a very complicated pattern owing to the effects of relief and aspect, which mask the true motion of the belt. To see the motion clearly these effects must be eliminated. To this end the "isopercentage" method has been used, and it is believed that this is the first time it has been applied to the study of the rainfall of East Africa.

By the isopercentage method the average monthly rainfall is expressed as a percentage of the average annual total. Places having the same percentage of their total annual rainfall in a given month are joined by lines which, for want of a better word, are called iso-

percentage lines. Such lines are independent of relief. Two places on opposite sides of a mountain range and having annual rainfalls of 30 in. and 100 in. would be joined by an isopercentage line if they received 3 in. and 10 in. respectively in any month. Such lines will therefore be much smoother than the isohyets and by comparing the maps for consecutive months the progressive movement of the rain-belt can be clearly seen.

When using this method it is not necessary to plot individual stations. The percentage value is the same over quite a large area and it was found convenient to choose the one-degree square as the unit. The original maps were drawn on a larger scale and lines were inserted at intervals of 10 per cent, but the movement of the rain-belt from month to month was found to be most clearly shown by drawing a single line at a value of 8½ per cent and shading the area having a greater percentage than this. Thus all places which have received more than one-twelfth of their annual precipitation are shown as being in the rain-belt.

These maps (Figure 2) clearly show the motion of the rain-belt which will be seen to pass across areas well known to be semi-arid. The salient feature of this method of presentation is that a comparatively small fall in such areas is as significant as a large fall in areas of heavy rainfall. Thus a sequence of smooth lines may be drawn across the maps, and the very smoothness of these lines may lead to suspicion as to their accuracy. The reasons for this smoothing may be summarized as follows:—

(1) The choice of the one month period, which has the effect of masking short-term oscillations of the rain belt.
(2) The use of average monthly and annual values obtained from records extending over as many years as possible.
(3) The use of percentages as explained above.
(4) The use of one-degree square as the unit.

The one-degree square was first chosen to reduce the amount of work entailed in computing and mapping. The figure for each square was obtained by averaging the monthly and annual rainfall figures for all stations in the square; in some cases there were over 100 stations, in others only one. There may be objections from a statistical point of view to the use of a raw average, but it was felt justifiable at the present stage of development, when in any case there are few or no records from so many degree-squares. The generalized nature of this presentation must therefore be accepted as the best that can be done at present, its justification being that it clearly shows the way the rain-belt moves.

It must be admitted that there will be instances where a small feature has been obliterated by the rather arbitrary definition of the rain-belt, in having selected a 12-month period and an 8½ per cent line. For example, Lamu has two rainy seasons, one being much more pronounced than the other, 71 per cent of its annual rainfall falling in the three months April, May and June. This leaves only 29 per cent for the remaining nine months, no one of which reaches a figure of 8½ per cent (*see* Figure 4) so that on the map the rain-belt appears to avoid Lamu on its southward movement in October.

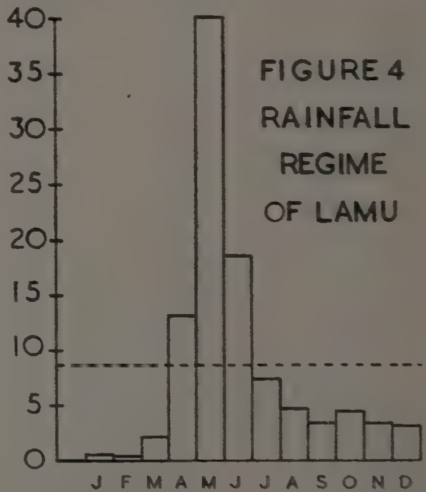


FIGURE 4
RAINFALL
REGIME
OF LAMU

It is not thought that this error invalidates the method used on the series of maps produced. Errors of this type can only occur where there are two rainy seasons, and the particular station chosen (Lamu) experiences a greater inequality between the two seasons than is likely to be met anywhere else in East Africa.

The average monthly distribution of the rains over the whole continent of Africa is shown in Figure 3 by a series of 12 monthly charts. These maps, which were prepared from the publications of the countries concerned, provide the background against which the rains in East Africa may be considered in more detail. The southward movement of the rain-belt during September to

December and the northward movement in March to June are clearly shown. The rain-belt pauses in the North for the months of July and August and in the South during January and February.

Referring to Figure 2, it will be seen that in January the rain-belt covers all of Tanganyika south of a line from Dar es Salaam to Lake Victoria. There is not much change in February, but a significant bulge is observed in southern Kenya in the Nairobi area although at the Tanganyika coast the rain-belt temporarily recedes southward. In March there is a general movement northwards and the bulge has extended right across central Kenya to the Northern Frontier. All the Lake Victoria area is now receiving more rain, and the rain is also moving northward along the coast. By April rain has become general over all the East African territories. In May the rain has finished over most of Tanganyika, but it still persists over a broad strip between the central plateau and the coast. A dry strip north-east of Kilimanjaro and east of the Kenya Highlands now appears, the significance of which becomes apparent in June, when the rain-belt is seen to have split into two parts, one at the Kenya coast and the other over western Kenya and northern Uganda. The western part of the belt remains almost stationary during July and August but the eastern part has moved right out of East Africa and is presumably to be found over India. In September the rain-belt has reached into Uganda; part of East Africa is experiencing complete drought, except for occasional showers in eastern Kenya and at the coast. The short rains first appear in late September or early October in north-eastern Kenya, this being in fact the reappearance of the eastern part of the inter-tropical rain-belt. They become fully established in November by the linking-up of the two parts but this is accompanied by a southward movement in Uganda so that the alignment is from north-east to south-west; it should also be noted that the coast, with the exception of the area round Dar es Salaam, appears to remain comparatively dry. The southward movement continues in December, so that the whole of Tanganyika except a part of the coastal strip receives rain, but the movement is slower in the inland parts of Kenya east of the Rift Valley. By January the rain-belt has completely left Kenya and is again confined to Tanganyika.

The next step, having established the "normal" behaviour of the rain-belt, is to study individual seasons, in particular to draw maps to watch the development of a current season. Maps have been drawn for the years 1948, 1949, 1950 and 1951. From this series of charts there are hopeful signs that if it were extended over a sufficiently long period it might be possible to discover the most frequent paths of movement in relation to air-flow. If it were found that in a particular season the rain-belt had started to move along an already known path, at an observed rate of intensity, it might be possible to forecast the seasonal development. This would only be possible if information from rainfall recording stations could be sent in more quickly and more frequently than at present; in fact weekly maps might be tried in preference to the monthly ones.

It would not be necessary, by this method, to have information sent in from all the observing stations. A representative selection would suffice. As weekly information is already available from a fairly large number of observing stations, the cost of operating such a scheme would be almost negligible and involve but little extra work.

It will be seen that the isopercentage method combined with the degree-square presentation has resulted in a simplified picture of an element which, because of its extreme variability in time and space is acknowledged to be difficult to present in a simple manner.

The method would seem to be most useful when applied to the inter-tropical regions of the world. There can be little doubt that the approach to the problems of East African rainfall would be facilitated if figures were made available on a continental basis, to include at least all countries south of the Sahara. If this were successful it might well prove possible to apply the same methods to South and Central America and to Asia-Australasia.

Acknowledgment

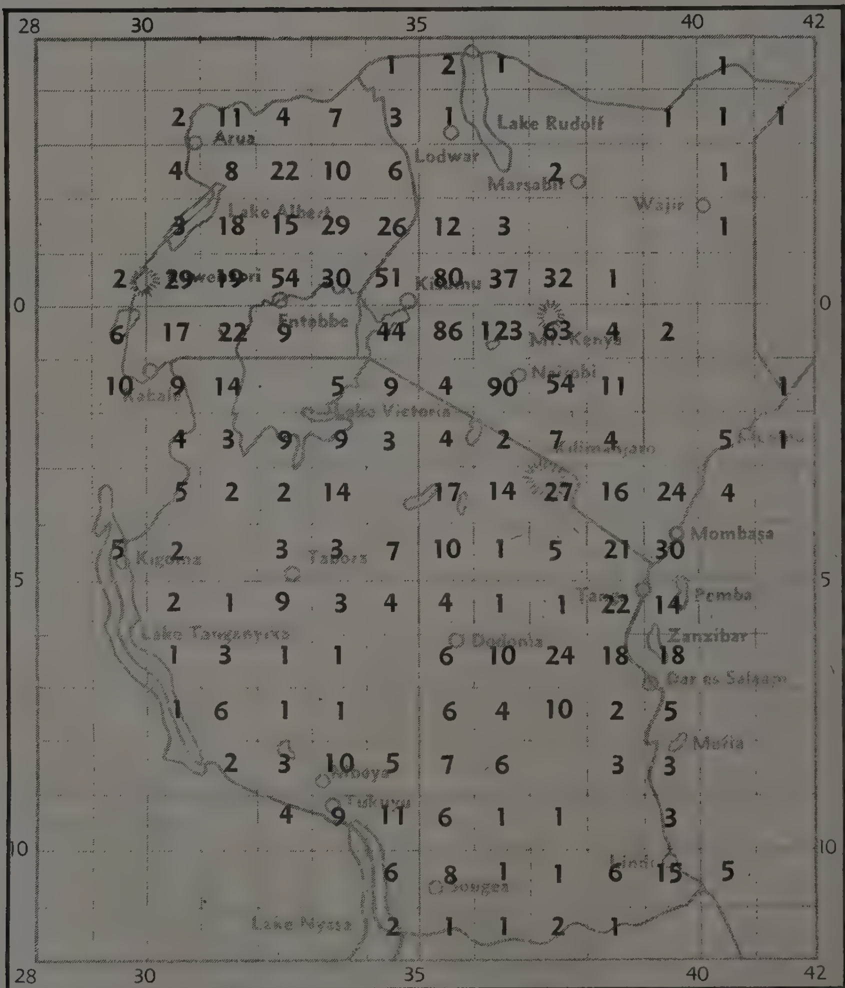
I am much indebted to Mr. R. W. Walmsley for assistance and encouragement in compiling this paper and to Mr. Ballard for assistance in the preparation of the maps for reproduction.

My thanks are also due to the Meteorological Services of Southern Rhodesia, Portuguese East Africa and Angola for sending me their rainfall statistics and to the East African Meteorological Department for access to records and publications.

I am grateful to the Director of the East African Meteorological Department for permission to publish this paper and to Dr. H. C. Pereira for editorial assistance.

Fig. 1

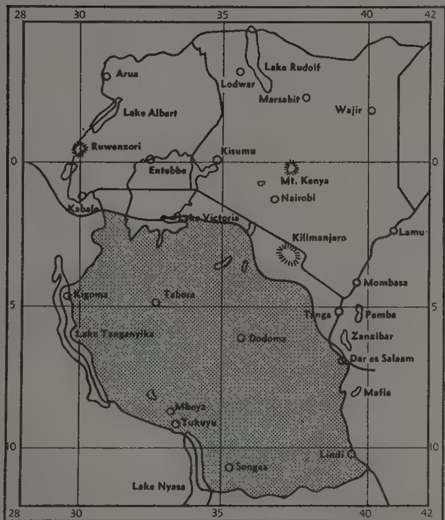
EAST AFRICA



Number of Rainfall Stations is each Degree Square

Fig. 2

EAST AFRICA



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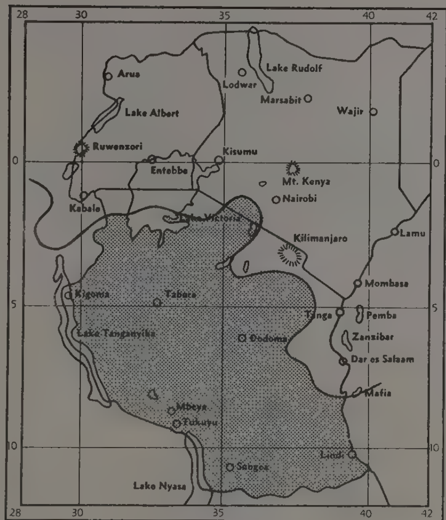
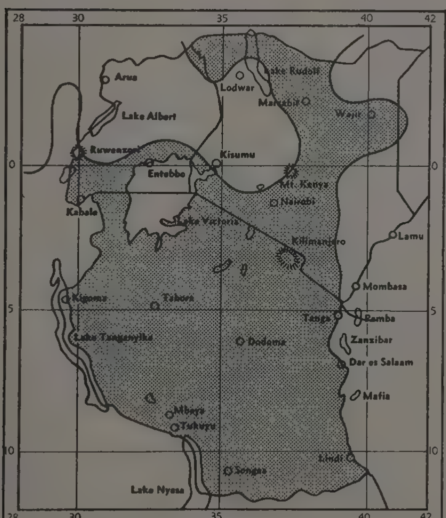
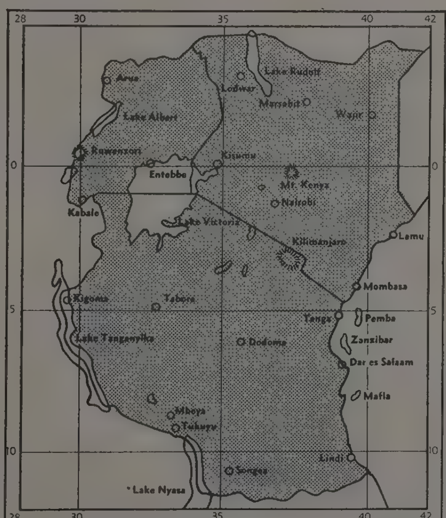


FEBRUARY



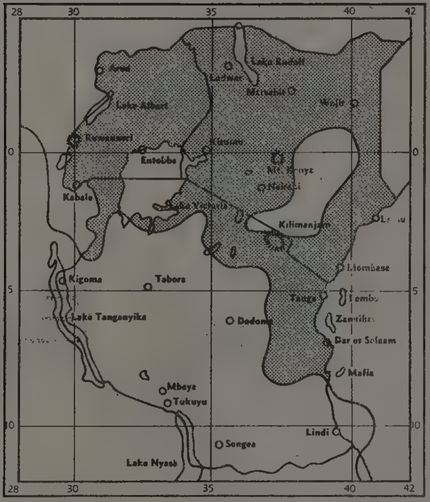
MARCH



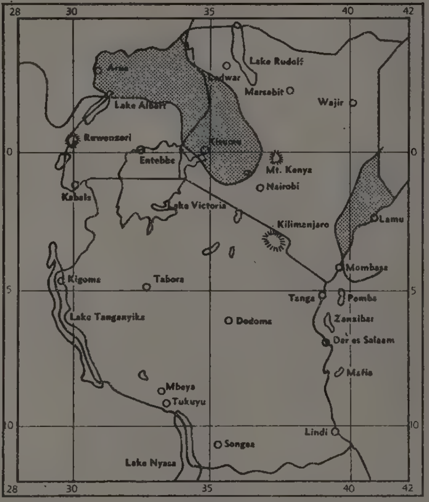
APRIL

Fig. 2

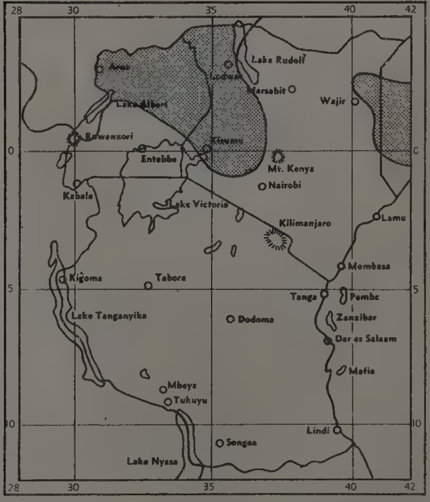
EAST AFRICA



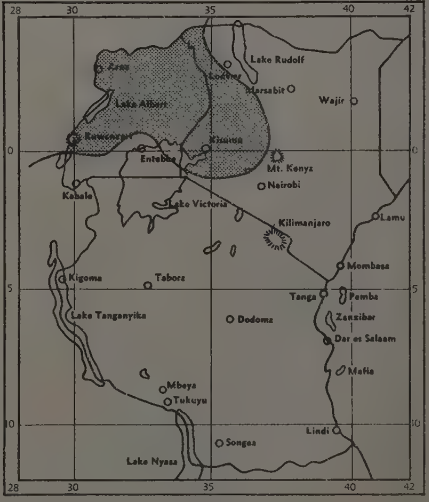
MAY



JUNE



JULY



AUGUST

Fig. 2

EAST AFRICA

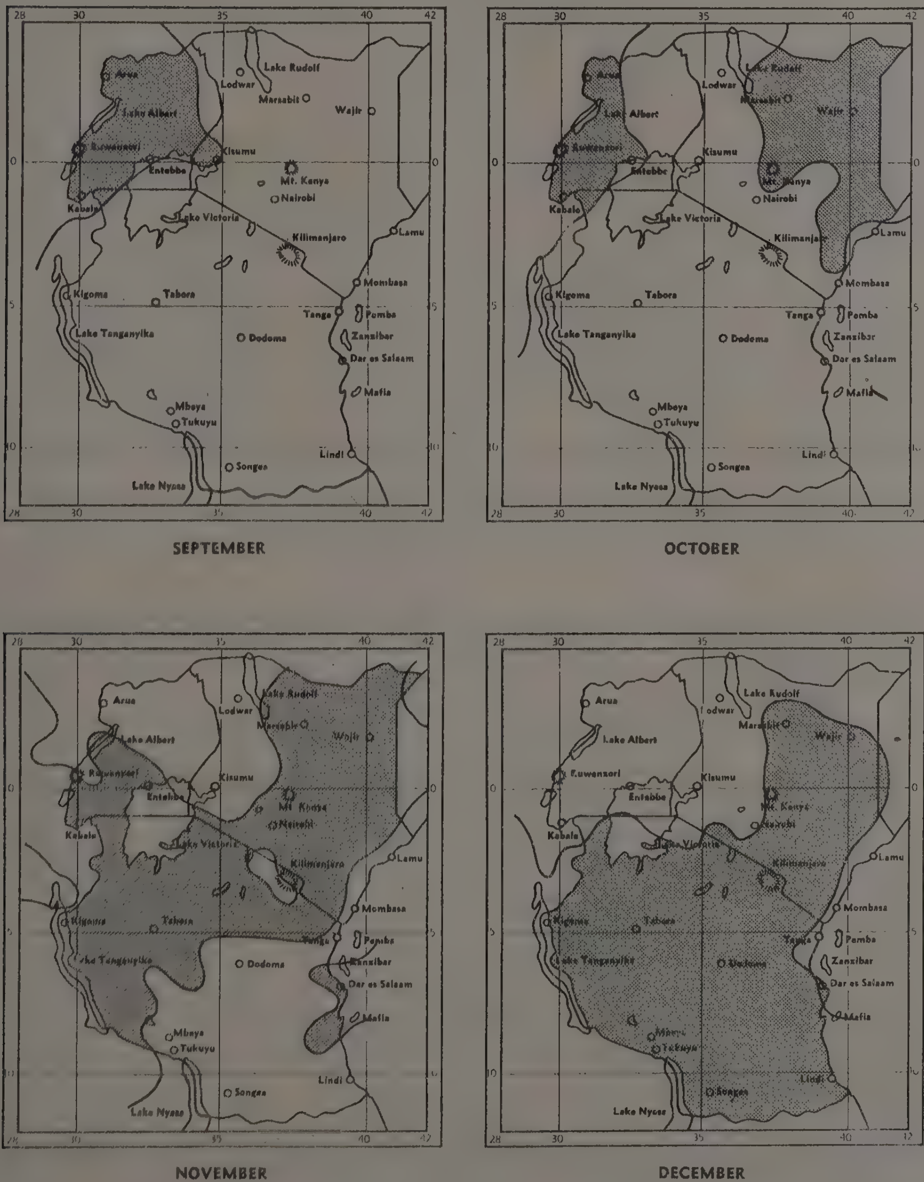
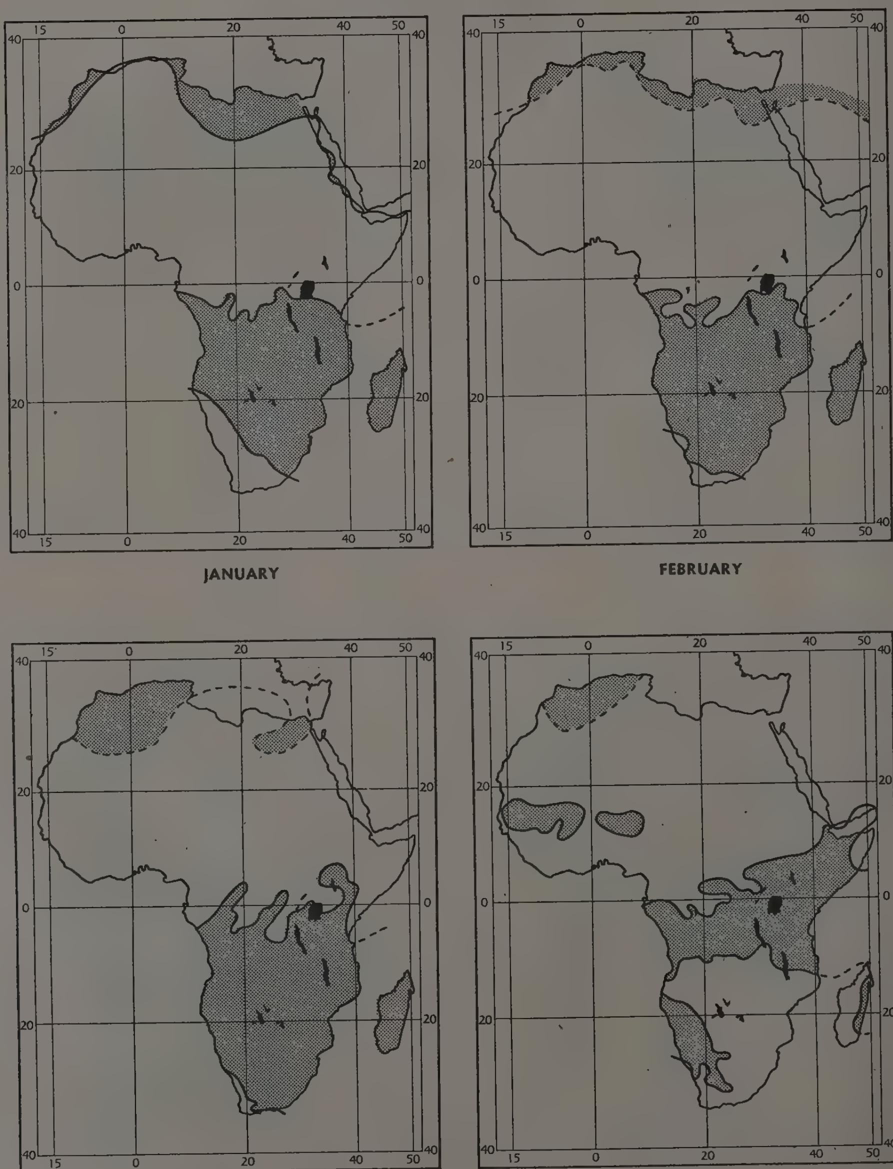


Fig. 3

AFRICA



JANUARY

FEBRUARY

MARCH

APRIL

Fig. 3

AFRICA

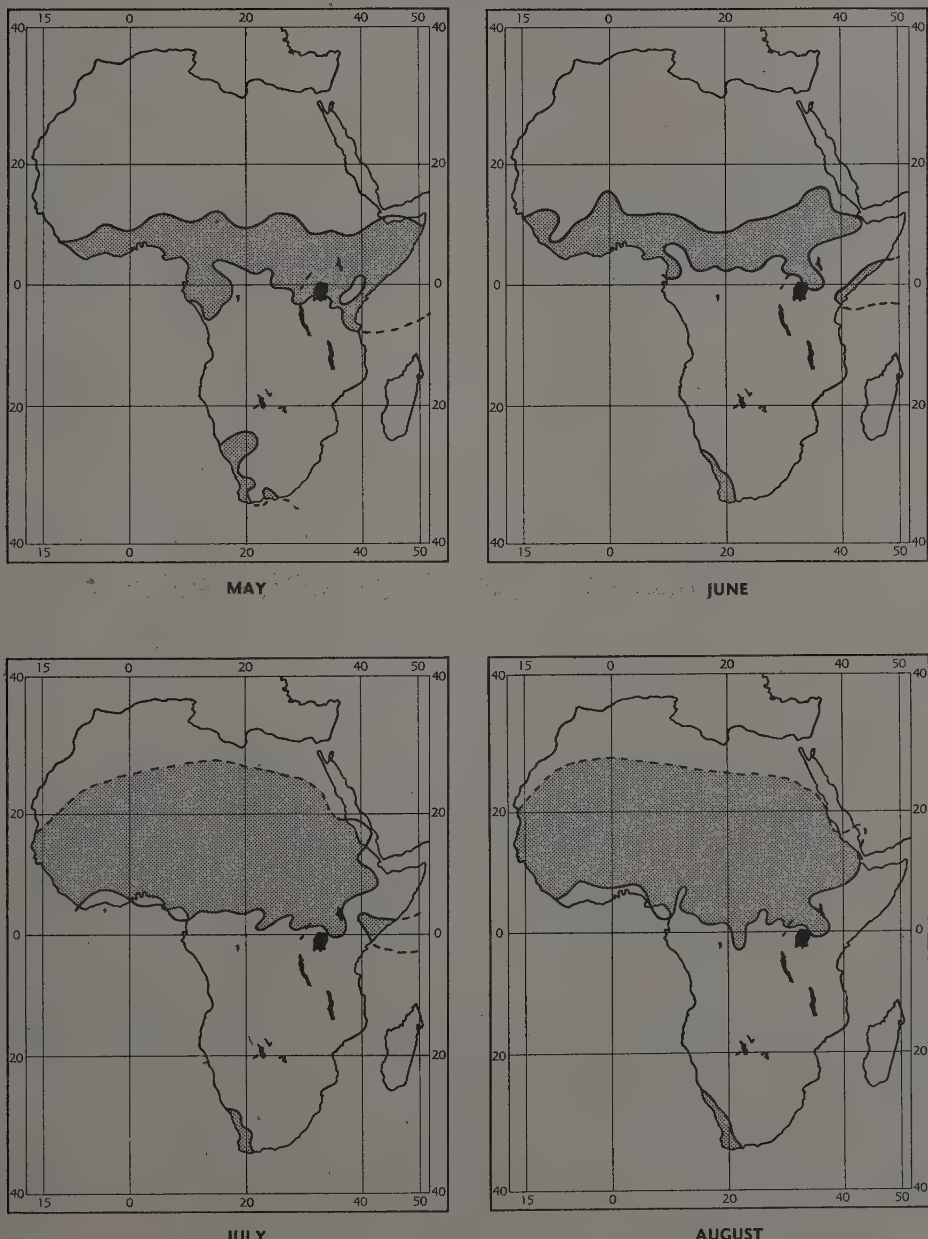
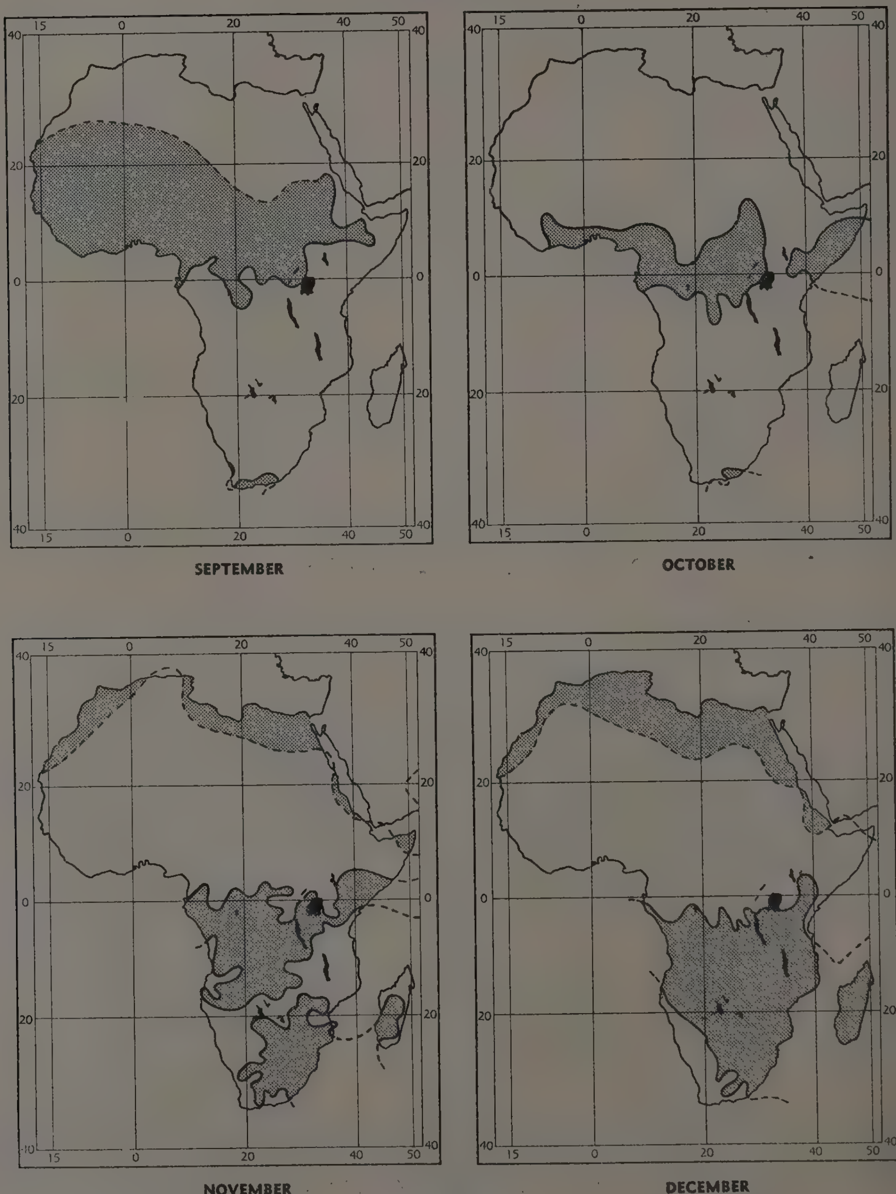


Fig. 3

AFRICA



PILOT SCALE MANUFACTURE OF HECOGENIN FROM SISAL WASTE

By M. G. Edwards, Chief Chemist, East African Industrial Research Board

(*Received for publication on 11th June, 1952*)

In the course of an investigation by the Medical Research Council into possible raw materials for the synthesis of cortisone [1], it was discovered that the substance hecogenin could be derived from the East African sisal plant, *Agave Sisalana* Perrine.

Hecogenin is likely to prove a much more suitable starting material for the manufacture of cortisone than deoxycholic acid or cholic acid which are at present used, both from a chemical point of view [2] and because it would not be limited in supply as are the latter materials.

As a result of a survey of East African sisal in Kenya and Tanganyika, Dr. P. C. Spensley of the National Institute for Medical Research, continuing the investigation of the Medical Research Council mentioned above, found that the best source of the saponin yielding hecogenin was the juices obtained from the more mature leaves of the plant [3]. Thus, assuming the normal plant to produce an average of about 230 leaves, the last 80 to 100 leaves cut would yield a fair quantity, while the first cut of leaves would yield practically no hecogenin. Further, the juice from the butt half of the leaf involves the introduction of considerably less impurities which lead to difficulties in processing.

Production of Juice

For the reasons already stated the older leaves are used. They are put through the decorticator in the ordinary way, except that the water is cut off from the drum processing the butt half of the leaves. This is one necessary modification of the usual procedure and would involve on a large scale incorporating a conveyor system of some sort to carry away the waste which would in the normal way be washed down the flume. A second modification is the necessity of washing the fibre by means of a jet of water, by dipping in a trough of running water, or by some such means. These alterations to the normal process can be comparatively easily instituted and would not cause any loss in output or in the quality of the line fibre produced.

In this preliminary pilot work, the waste has been raked out of the decorticator discharge chute and carried to the squeeze rolls, which are normally used for dewatering the flume waste preparatory to separating the flume tow. The waste is passed through these rolls when a juice is exuded from which small amounts of fibre and particles of other material are removed by passing through a large funnel fitted with a wire mesh screen. In this way up to 50 per cent of the weight of the original leaves can be obtained as an opaque green liquid. The juice is collected in 44-gallon drums and on standing deposits solid matter, which after several days settles to a slurry occupying about one-quarter to one-third of its volume.

Active fermentation with visible evolution of carbon dioxide takes place for two or three days with the formation of acids, particularly acetic. Thus in one case, a juice initially containing 0.02 per cent of volatile acids at a pH of 4.7, gradually increased to a maximum of 0.75 per cent volatile acids at a pH of 3.97 in about a week. Consequently, particular care must be taken to vent drums containing fresh juice at intervals, as otherwise considerable pressure of CO_2 may develop.

Processing of Juice

The laboratory process, as previously reported [3], is closely followed.

The drums of juice are delivered to the laboratory soon after processing and are then allowed to stand for 10 days, after which time the supernatant layer of clear liquor, which on testing yields only approximately 0.01 per cent of hecogenin, is siphoned off to waste and the thick underlying slurry only is treated, which contains the equivalent of about 0.2 per cent hecogenin.

Sixty gallons of the slurry, obtained from about 160 gallons of juice, are transferred to a copper vat of about 70 gallons capacity erected as shown in figures 1 and 2. The vat is heated by a petrol pressure burner, which was most convenient to install at the laboratory, though on a larger scale more conventional methods would be applied. The slurry is acidified with three gallons of sulphuric acid (85-90 per cent), heated to boiling and maintained within 5° C. of this temperature for three hours. A normal solution of free mineral

acid is about the minimum required to bring about the hydrolysis of the saponin from which the hecogenin is derived. The juice contains considerable quantities of calcium, magnesium and potassium salts of organic acids, which vary greatly, depending on the district from which the juice is obtained. Consequently a considerable excess of acid, over and above the theoretical, is required to bring the concentration of free mineral acid up to normal.

Nine pounds of activated carbon are then added and the mixture is now allowed to cool and is stirred occasionally for one hour. The hecogenin is precipitated with the carbon and after standing over-night, the clear dark brown overlying layer of liquor is siphoned off to waste by means of a 1 in. diameter rubber hose. The settled carbon, which forms a layer about one-third of the depth of the liquid, is washed by decantation four or five times with 50-gallon lots of water, until the acidity has been reduced to below N/30 (0.16 per cent w/v H_2SO_4).

The carbon layer is then neutralized with caustic soda (phenolphthalein) and sufficient excess added to bring the concentration to about 0.1 per cent. It is then transferred to an electrically-heated drying tray of about 20 sq. ft. area. The carbon takes about three days to dry and the heating is so arranged that the temperature at no time rises above 100° C., the bulk of the material being considerably below this temperature.

The carbon dries into a compact sheet about half an inch thick, and when dry is broken up into pieces of about 1 cu. in. in volume. From 15 to 18 lb. of this material is obtained.

Extraction of the Activated Carbon

For this purpose a 5-gallon capacity Soxhlet unit is used. The dried material in the lump form is extracted for 24 hours with carbon tetrachloride. Finely powdered carbon will not extract at all well, whereas it was found that the lump material is almost completely extracted.

The carbon tetrachloride solution is evaporated to dryness and the residue taken up in about three gallons of alcohol in two or three batches using laboratory glassware. The hot solution is quickly filtered and the filtrate allowed to crystallize overnight. The crystals are removed and the mother liquor evaporated to about half its volume, when a further small crop of crystals is obtained. The total yield of this crude hecogenin, which is rather variable, is about 1½ to 2 lb. per batch of slurry, or roughly 0.1 per cent of the original juice.

Mention of yields of hecogenin above, refer to crude hecogenin determined analytically, that is, ether insoluble material obtained in the extraction process put forward by P. C. Spensley [3], which yields about 60 per cent of pure hecogenin on further processing.

It is, of course, possible to utilize juice from the whole sisal leaf, instead of just the butt half, but whilst there is an adequate supply from the latter alone, this is to be preferred.

The normal run of the butt half juice used averaged about 0.08 per cent crude hecogenin and about 2,000 gallons of juice are obtained per ton of line fibre produced, by the somewhat rough and ready methods used, and without doubt this yield of juice could be greatly increased by the use of more suitable presses. The yield of crude hecogenin should, therefore, be at least 16 lb. per ton of fibre produced.

The Medical Research Council has applied for a patent, provisional specification No. 6579/52, covering the operation of the process. This application will be assigned to the National Research Development Corporation for development and exploitation and this latter organization intend to file corresponding patent applications to protect the invention in all the appropriate overseas territories.

ACKNOWLEDGMENTS

Acknowledgments are due to Messrs. Mitchell Cotts and Co. Ltd., whose subsidiary E.A. Sisal Estates, Ltd., supplied all the raw material and particularly to Mr. R. E. Rodseth and Mr. I. S. Robertson of the latter company, who actually undertook the work of supplying the juice and of preparing juices from various sources for ancillary experiments. Acknowledgments are also due to the staff of the E.A. Industrial Research Board who assisted in this work and also to Dr. P. C. Spensley of the National Institute for Medical Research, who was responsible for the original method of processing the juice and has been closely associated with this pilot plant study while working in the Board's laboratories and who has made various suggestions and corrections to this paper.

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[1] "A Source of Hecogenin" by R. K. Callow, J. W. Cornforth and P. C. Spensley, *Chemistry and Industry*, 1951, p. 699.

[2] East African Industrial Research Board Ninth Annual Report 1951, p. 6.

[3] "A Source of Hecogenin" by P. C. Spensley, *Chemistry and Industry*, 1952, p. 426.

Fig 1.—Showing on left copper vat insulated with hessian and petrol burner operated by compressed air. Flexible air lines are also utilized for unloading slurry from the drums and for decanting acid from the carboys.

Fig 2.—Showing drying tray, which is charged directly from the vat. At the back right is the unit Soxhlet Extractor. The filter press is not now used in the process.

BOLE ROT OF SISAL

By Maud M. Wallace, Plant Pathology Laboratory, Lyamungu

and

E. C. Diekmahns, Plant Physiologist, Sisal Research Station

(*Received for publication on 21st April, 1952*)

Introduction

Rotting of sisal boles first came to the attention of the Plant Pathology Laboratory about 20 years ago when it was found on a few plantations in the Eastern Province. Later it appeared in the Tanga district, and at the present time it causes increasing concern in most sisal areas of Tanganyika.

The first infections were observed to start at leaf stumps after cutting, and this was followed by a rot extending into the boles and ultimately killing the plants. The rot was finally soft, wet and evil-smelling, as a result of the action of secondary rotting bacteria and fungi. Out of many organisms isolated at that time from rotting boles, the only one which was found able to produce any necrotic effect on the sisal plant, when artificially inoculated was the fungus *Aspergillus niger*, and this only to a very limited extent. When this was introduced into small wounds in leaves, lesions of up to one inch in diameter were produced. The fungus was found to be incapable of penetrating uninjured epidermis [6].

Dr. H. H. Storey later successfully reproduced the disease in one out of three freshly dug-up suckers by inoculating tissue from a diseased plant, but similar inoculations with tissue from this sucker into three already established suckers in tins were unsuccessful [4]. From these results, combined with the fact that *A. niger* is normally regarded as a saprophyte, or at most as a weak parasite, the inference was drawn that there was some predisposing factor which rendered sisal susceptible to attack by such a weakly parasitic organism. In the early studies the disease was seen to have more effect on plants cut during the wet season than in the dry; but weather alone did not in all cases appear to explain the presence of bole rot, and it was suggested that one cause predisposing the plants to attack might be the lack of some major or minor element in the soil [6]. Preliminary experiments were set up on a few sisal plantations, but as they could not be personally supervised, no results were obtained. It was claimed that on one estate the incidence of bole rot was greatly reduced by removing and destroying affected boles.

Other theories accounting for bole rot have been put forward. Den Doop stated [2] that an excess of some plant nutrient in the soil was the cause. There is some evidence that calcium deficiency may be associated with the progress of the disease in the plant, but that some parasitic organism plays a part [1]. The latter possibility has been reinvestigated, and this paper reports the results.

Two apparently distinct types of bole rot were studied: the common widely distributed Wet rot which is the type referred to above; and a dry rot, designated Basal dry rot, which had been seen on one estate only. What is possibly a third form of bole rot is known to occur in the Southern Province; this we have not seen but hope to investigate when an opportunity arises.

Wet Bole Rot

The main symptoms of the Wet Bole Rot are as follows:—

(1) Affected plants can be recognized in the field by their pale colour.

(2) Almost invariably infection occurs through cut leaf bases and spreads inward into the bole and to adjacent leaf stumps. Figure 1.

(3) The rot is soft and evil-smelling.

(4) The affected leaf base and bole tissues are yellow to brown in colour, with bright pink at the outer margins.

(5) When split longitudinally, an affected bole shows that there is no sharp differentiation between rotted and healthy tissue.

(6) Affected boles are not, typically, injured below ground level.

(7) Weevils are frequently, but not invariably, found in the rotted tissue.

In order to determine whether a pathogenic organism is the cause of disease in plants it is usual to extract small pieces of tissue aseptically from the edge of the affected part and to place these on plates of sterile agar (jelly containing sufficient food substances to maintain

growth of fungi or bacteria). Any organisms which develop are then grown in pure culture in test tubes and later inoculated into healthy plants to discover whether they are capable of causing the original symptoms. In the case of Wet Bole Rot of sisal this procedure yielded three different organisms, a black-spored fungus *Aspergillus niger*,* bacteria, and a yeast-like fungus. Inoculation into healthy young sisal showed that the two latter were incapable of setting up rot but that the fungus *A. niger* set up a very pronounced rot, evidence of which was visible after two days. These tests are described more fully below.

The inoculation trials were carried out on young rooted bulbils growing in pots in the laboratory. The fungus was introduced into three series of plants in the following ways:—

1. Leaf cut off and the cut surface on the plant inoculated.
2. Bole inoculated by needle-prick.
3. Inoculum put on bole without wounding.
4. Small cut made in leaf-blade and inoculum put in cut.
5. Leaf-blade inoculated by needle prick.
6. Inoculum put on leaf-blade without wounding.

After inoculation, one series of bulbils was kept in a moist atmosphere for five days by placing the plants under a bell jar wetted on the inside; a second series was similarly kept damp for two days; and a third series was left in the dry air of the laboratory from the time of inoculation. Controls were kept, i.e. leaves and boles were pricked or cut with sterile needles or knives but without inoculation.

None of the control plants developed rot, whereas rotting was produced in every case where the fungus was introduced into the plants with a wound and kept in a damp atmosphere for at least two days. The rot set up was soft and wet and spread rapidly, eventually killing some of the plants. It is significant that the series of bulbils inoculated but kept in a dry atmosphere showed no rot at all, and where no wounds were made no rot developed. The same fungus *A. niger* was re-isolated from the infected bulbils. The following table summarizes the results.

* The identity of this fungus was later confirmed by the Imperial Mycological Institute as "*Aspergillus niger* v. Tiegh. in the strict sense".

The experiments with young rooted bulbils were preliminary experiments only, to find out whether this fungus could cause extensive rotting of sisal tissue. The results seem quite clear: that under certain conditions, namely the presence of the fungus, a damp atmosphere and the presence of wounds, *A. niger* can cause a soft wet rot of very young sisal plants similar to the rot found in mature sisal in the field. This result confirms the findings of the early trials.

The fungus *Aspergillus niger* is a common soil fungus and is usually regarded as saprophytic (i.e. living on dead organic matter and therefore not a cause of disease), or weakly parasitic only. It has, however, recently been identified as the organism responsible for a crown rot disease of groundnuts in Queensland [3] and in Tanganyika [5]. Whether it is to be regarded as the sole cause of Wet Bole Rot of sisal depends on work in progress at Mlingano. It may be found that some other factor is concerned, such as a chemical deficiency in the soil rendering plants weakly and therefore more susceptible to attack by this fungus.

BASAL DRY ROT

Basal dry rot shows certain features which are similar to those of Wet Bole Rot; namely, it is a fatal disease; affected plants can be distinguished in the field by their unhealthy colour, and there is the same bright pink colour associated with the rotted tissue. The chief points in which Basal Dry Rot differs from Wet Rot are as follows:—

(1) Uncut as well as cut plants are affected.

(2) Infection occurs at the base or side of the bole below soil level, and spreads upwards forming a cone-shaped zone of rotted tissue. Figure 2.

(3) The rot is dry rather than wet, and affected tissues are hard.

(4) The colour of the rotted area is grey-brown (with invariably some pink coloration at the base and often at the upper extremity of the diseased tissue).

(5) Healthy bole tissue is separated from diseased by a fairly sharp wavy line of darker brown.

(6) There is no foul smell.

(7) All affected plants showed injury of some kind below soil level—weevil, white ant or mechanical injury.

RESULTS OF INOCULATIONS WITH *ASPERGILLUS NIGER*

Method of Inoculation	Damp Chamber Five Days		Damp Chamber Two Days		Dry Atmosphere of Laboratory		Remarks
	No. of inoculations	No. of infections	No. of inoculations	No. of infections	No. of inoculations	No. of infections	
(1) Leaves cut off, cut surfaces on plant inoculated at once.	6	6	2	2	2	0	Typical soft yellow-brown wet rot, extending downwards into bole.
(2) Bole inoculated with prick.	2	2	1	1	2	0	Typical soft rot. Affected area 1 cm. diam. after 7 days. Spread into leaf from bole after 17 days.
(3) Bole inoculated—no wounds.	2	0	—	—	4	0	Indicating that the fungus is unable to penetrate uninjured tissue.
(4) Cut made in leaf blade and inoculated.	3	3	3	3	—	—	Brown rotted areas, 2½ cm. in length after 7 days. After 17 days whole leaf blades except extreme tips were rotted.
(5) Inoculated into leaf blade with needle-prick.	4	2	—	—	3	0	Similar to No. 4.
(6) Leaf blade inoculated, no wounds.	5	0	3	0	6	0	*See* remarks for No. 3.
(7) Leaves cut off: cut surfaces on plants inoculated after twenty-four hours.	—	—	4	0	—	—	Indicating fungus is unable to penetrate tissue after it has dried out.
(8) As 7, but drop of sterile water added.	—	—	2	2	—	—	Indicating that with moisture (e.g. rain) penetration by the fungus is possible.

The same procedure for isolating any pathogenic fungi or bacteria from diseased boles was undertaken. The only organism which developed in the cultures was the same black-spored fungus, *Aspergillus niger*. When affected boles were split and left for two days in an enclosed space, almost the whole of the rotted surface was covered with fructifications of this fungus (Fig. 3). The conclusions from this part of the study, so far as it has proceeded are: (1) that both Wet Bole Rot and Basal Dry Rot are different manifestations of the same disease; (2) that both are associated with the presence of the fungus *Aspergillus niger;* and (3) that whether the rot is to be dry or wet possibly depends upon environmental circumstances, or upon the chemical status of the plant.

The results obtained in this preliminary investigation seemed to justify experiments on a larger scale using the fungus isolated in pure culture to infect mature sisal plants in the field. This is being carried out at the Sisal Research Station, Mlingano, and the results, to date, form the second part of this paper.

Field Trials at Mlingano

Field trials were laid out at Mlingano to investigate the effect of inoculating two-and-a-half year old sisal with *A. niger*, isolated and subcultured at the Plant Pathological Laboratory as described above.

Experiment 1

Uncut two and a half year old sisal, planted in single rows spaced 2.5 m. by 1 m., had single leaves cut from them and the exposed leaf bases were treated as follows:—

A. Lower leaf control.

B. Upper leaf control.

C. Lower leaf sterilized with 10 per cent formalin.

D. Upper leaf sterilized with 10 per cent formalin.

E. Lower leaf inoculated with *Aspergillus niger.*

F. Upper leaf inoculated with *Aspergillus niger.*

The six treatments were randomized and applied to single plant plots, replicated six times.

After the date of inoculation (27th February, 1950) there was a dry period of two weeks, followed by heavy rain.

After eight weeks 50 per cent of the inoculated plants in the above trial showed a positive take with the rot spreading to other leaf bases; 25 per cent showed that the inoculation had taken but that the spread had been arrested; 25 per cent showed no take. Control plants and those sterilized with formalin showed no signs of rotting. Twelve weeks from the date of inoculation, the plants were again inspected. There was no change in the results as expressed above except that where the rot had been recorded as spreading, a few more leaf bases were affected. Mycological examination of the bole of a successfully inoculated plant at this time showed no sign of the fungus having invaded the bole.

Inspection of this trial eight months after inoculation showed that the rot which had commenced in the inoculated plants had apparently been completely arrested. In no case were more than five leaf bases affected on one plant.

In view of the limitations imposed by the single plant plots in this trial, a further trial was laid down with plots of twelve plants and with a slight variation of the original treatments.

Experiment 2

The following treatments were applied to plants of the same planting age and spacing as in experiment 1. A treatment to investigate the effect of severity of cutting on the degree of take was included. The sterilizing agent was changed from 10 per cent formalin to 0.1 per cent mercuric chloride in view of the slight scorching effect which the former had shown in the original trial.

Treatments

Sisal heavily cut (to 12 leaves)—

A. Control.

B. Sterilized with 0.1 per cent mercuric chloride.

C. Lower leaf base inoculated.

D. Upper leaf base inoculated.

Sisal lightly cut (to 24 leaves)—

E. Control.

F. Sterilized with 0.1 per cent mercuric chloride.

G. Lower leaf base inoculated.

H. Upper leaf base inoculated.

The eight treatments were randomized and applied to 12-plant plots and replicated four times. The plots were split for the application of the inoculum to either the east or west side of the plant.

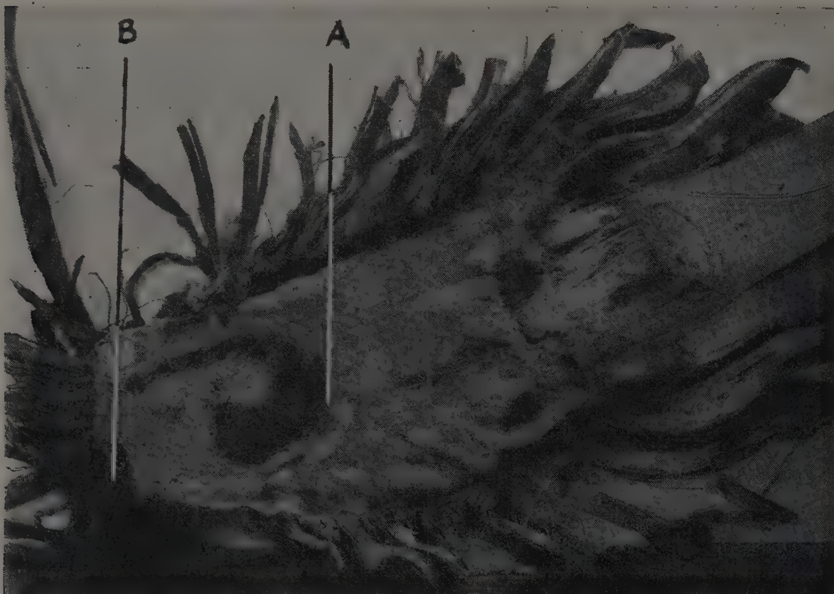
There was a light but even distribution of rainfall almost every day for two weeks after the date of inoculation, 5th July, 1950.

The results for the inoculation treatments C, D, G and H showed the following percentage takes after four months:—

	Per cent
C	97.9
D	74.5
G	81.8
H	93.5

The other four treatments showed no rotting of leaf bases.

These results are significant in respect of the effect of inoculating sisal plants with *Aspergillus niger,* as opposed to the control and sterilized plants, but are not significant in respect of the severity of cutting and of the site (lower or upper leaf base) of inoculation. The split plot treatments showed no significant effect of aspect.



Basal dry rot. Bole split longitudinally showing: (1) diseased area between A and B; (2) the intense black portion curving round the edge of the diseased area is due to the formation of spores of A. niger. The fungus has grown out from the underlying tissue; (3) injury at B, where the fungus originally entered the bole; (4) healthy tissue.

Fig. 1.—Wet bole rot spreading inwards from cut leaf base.

Fig. 2.—Basal dry rot spreading from base upwards.

As a measure of the rate of spread of *Aspergillus niger* within the sisal plant, the total number of leaf bases which have rotted under the various inoculation treatments is as follows:—

	No. of Original "Takes"	After 2 months	After 4 months
C	47	105	126
D	35	104	194
G	36	58	122
H	44	171	251

So far, no mycological examination of bole tissue has been made to ascertain if the fungus has penetrated to this region. However the appearance of several of the plants where the fungus has spread to leaf bases completely surrounding the bole indicates that they will eventually succumb to the effects of the inoculation. A few plants had as many as 35 rotten leaf bases each.

Discussion

The two experiments described indicate that a rot comparable in the initial stages at least to Wet Bole Rot as found in the field, can be induced in the sisal plant by inoculation with *Aspergillus niger*. This induced rot has a slow rate of spread and in experiment 1 had not attacked the bole after three months, and after eight months appears to have been completely arrested. In experiment 2 recordings indicate that the rate of spread of the rot from one leaf base to another is more rapid in wet weather than in dry.

As stated in the first part of this paper, it has been suggested that the course of the disease may be controlled by the nutrient status of the plant and in particular by the calcium content. Field evidence certainly indicates that Wet Bole Rot is often associated with the chlorotic mottling of the leaves which has been shown in the laboratory to be linked with a low calcium content [1] [8]. In the two experiments under review, chlorotic mottle is present in many of the plants but to a very minor degree.

The leaf base necrosis as described by Den Doop [2] can only be interpreted as the initial leaf base rot which leads to Wet Bole Rot, and he attributes this to nutritional excesses. Evidence from these trials at Mlingano, however, shows that such a rot can be induced by *Aspergillus niger* in healthy sisal, although the effect that the nutritional status of the plant has on the course of the disease has still to be more fully investigated.

Control in the Field

With regard to the control of bole rot in the field the only suggestion which comes out of the present work is that where bole rot is prevalent, cutting should be confined to the dry seasons of the year. This will not only tend to reduce the initial infection by the fungus but will also reduce the subsequent spread of the rot. This suggestion is in conformity with that proposed by the Plant Pathologist [7] in 1939.

Further work is at present in progress to ascertain the value of spraying freshly cut sisal with various fungicides in an attempt to control infection by *Aspergillus niger*; but at this stage it is fairly obvious that all rotting sisal plants should be cut out and destroyed. Besides lessening the risk of further losses of plants due to Wet Bole Rot, this measure would also reduce numbers of the sisal weevil since this pest breeds prolifically in most evil-smelling rotten boles.

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THE TILAPIAS OF KENYA COLONY

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Origin of the Tilapia

Paratilapia with 30 species, and Tilapia with 60 species are distributed over a large part of Africa from the South Central regions, including Madagascar, northward to Asiatic Syria; and it may well be that these two genera are the most ancient and primitive migrants from Eastern South America.

The Cichlidae, Pomacentridae, Labridae, and Scaridae families form a progressive and specialized series that starts with the Cichlids. There are about 140 species of Cichlids extending from the United States to Cuba, and then covering the whole of Central South America. There are also about 150 species covering the whole of Africa south of the Sahara and north of the Cape Province, with a few in Madagascar. There are three species in Southern India. The American species are more ancient than the African, and the distribution of the Cichlids rather points to an American-African land bridge, which enabled the ancient species to spread to Africa from some centre in South America. The disappearance of this bridge may have been during late Oligocene or early Miocene time, the ancestors making the migration perhaps as early as the Cretaceous time. In other words the North American continent was a dispersal centre for fishes during Cretaceous-Eocene time. Due to earth movements and the biological outcome of such changes in their environment, the Cichlidae became split up into a series of localized groups, the South American, the African, and the South-East Asiatic. These groups became modified by their environment; but it is significant to know that Cichlids from the Grene River Shales in the United States and Cichlidae from the Miocene of Lake Victoria show very little difference from each other.

During Pliocene times extensive faulting took place over Central Africa, bringing about conditions as they are to-day. The Great Lakes of Africa, and the great swamp areas have existed from Eocene times; yet in the Pliocene time lakes, isolated swamps and river valleys were formed. In these, with their ecological niches, the ancient Cichlidae altered and developed the small separate characteristics which now form the modern species. It is interesting to note that other families of fishes, the Siluridae, especially its most ancient member the Bagrinae; the Characinidae (the Tiger fish, etc.); and Protopterus, the Lung fish, also came from a dispersion point in South America. On the other hand Barbus, Labeo and Barilius were of eastern primitive derivation, and came to Africa from China. Later the Nile Perch was derived from ancestors having an estuary habitat.

The Species of Tilapia

In Lake Victoria there are two species of Tilapia: *Tilapia esculenta* and *Tilapia variabilis. Tilapia nilotica* is found in Lake Rudolf, owing to its ancient drainage into and connexions with the Nile, and also in the relict Nilotic Lake Baringo.

Lake Magadi has another relict Tilapia from the times when it was Lake Kamasia; this is *T. grahami,* which has been modified by its soda environment into a tiny, highly-coloured fish.

The Athi and Tana Rivers, in those lengths situated between 5,200 ft. and 600 ft. altitude, are the home of *T. Nigra.* At about 600 ft. altitude this Tilapia is mixed with the Coast Tilapia, *T. mossambica,* which is also found in Lake Jilore, and in the shallow, hot, highly concentrated salt sea water of Formosa Bay. In Lake Jipe, according to Miss Rosemary Lowe of the East African Fisheries Research Station, Jinja, there are two Tilapia, *T. jipe* and *T. girigan,* closely resembling *T. mossambica.*

The other Tilapia is *T. hunteri,* of Lake Chale, and this is perhaps a relict of the old Tsavo-Athi River system, for both *T. nigra* and *T. hunteri* have four anal spines; the rest have three. In the past few years another Tilapia, *T. melanopleura,* has been introduced from the Belgian Congo; this also has three anal spines.

How to Tell the Species

For the ordinary person the quickest way is to count the anal spines. A three-spine fish from the Athi or Tana River is *T. mossambica;* a four-spine is *T. nigra.* (Fig. 1.) Both Lake Baringo and Lake Rudolf have only one Tilapia, with three spines; Lake Victoria has two three-spined Tilapia. Of these *T. variabilis* has usually a decided hump of the shoulders, with a lump over the eyes and more scales on the operculum; its blue-black back is also a distinctive feature. Therefore, knowing the

place of origin, the average person can tell the species.

With the introduced *T. melanopleura* (Fig. 2) one has much more difficulty in recognizing the fish. They are far more silvery in general appearance, and below the lateral line there is a pink sheen. They are far more lively, and will jump out of cans or any container on the slightest chance and will clear a seine net better than any trout. The young of *T. melanopleura*, *T. esculenta* and *T. nilotica* from Lake Baringo are as alike as peas in a pod and can only be recognized by habitat.

The Game Department will be stocking dams with *T. melanopleura* and *T. nigra* and there will be no difficulty in distinguishing the two species. *T. melanopleura* has three anal spines; *T. nigra* has four anal spines.

The scientist, however, has many points upon which he determines a species. Leaving out bodily proportions, gill-raker counts, numbers of rays, spines in the fins, and other points, the principal distinguishing character is the teeth of which there are two sets. One is a row of notched teeth set in the jaw bones on the top and bottom of the forward edge of the mouth; the other, and far more important set is the pharyngeal teeth. These are situated in the throat just behind the last gill-slit. The lower pharyngeal bone is a triangular plate, produced forward in a blade; on this triangular plate are numerous pointed teeth. The upper pharyngeal teeth are two oval patches, scattered all over with numerous fine teeth. It is the lower pharyngeal teeth which are used for identification, both as to the shape of the triangular plate and the nature of the tiny teeth themselves. These are removed intact on the plate, cleaned up, and then checked against those of other Tilapia and diagrams in technical papers.

Breeding

Tilapia are either mouth breeders or nest makers. Nest makers is not a good term as all species do this; *T. nigra*, *T. esculenta*, *T. variabilis*, and *T. nilotica* not only make the nest, but the female takes the eggs into her mouth and also takes her young into her mouth if danger comes. *T. grahami*, *T. mossambica* and *T. melanopleura* build a nest, and after the young are born, there is no more maternal interest. Nothing is known of the breeding habits of *T. hunteri*.

The cocks of some species of Tilapia put on a mating coloration, especially with advancing age. With *T. nigra* the body colours deepen very nearly to black, whilst the ocelli on the dorsal fin and anal fins also are crimson, and so is the anterior edge of the caudal fin.

Generally speaking, however, it is most difficult to tell the sexes of any Tilapia from an outside examination. The cock *T. grahami* of Lake Magadi can always be sexed at spawning time owing to its brilliant peacock blue coloration and males of *T. esculenta* also put on a breeding coloration when old, turning a slightly darker brownish colour, with no other distinguishing mark. The old cock fish of *T. hunteri* can be immediately recognized by his big head, long body, and blue-black coloration. The male *T. variabilis*, when ripe, has a blood red genital papila, a red tip to the dorsal fin, and a red edge to the caudal fin: the body colour is bluish black.

Food

The majority of Tilapia feed on the phytoplankton of the water they live in. The composition of this phytoplankton is very mixed and although a mass may be taken into the stomach, only certain organisms are digested, the rest being passed out.

There is very little phytoplankton in the Athi or Tana Rivers, even in the long still stretches where *T. nigra* can be found, and therefore *T. nigra* is a far more diverse feeder, living on mollusca, underwater insects and fish fry.

T. melanopleura is a weed eater in its older stages only; and it is most striking to see a pond stocked with these fish, for the grass edging is eaten away in a straight line. Fresh cut grass, lucerne, sweet potato tops, castor oil plant leaves, and chopped banana leaves thrown on to the surface of the water are grazed upon by the fish.

Growth Rates

The length a fish will grow each year of its life is most important to the Fishery Officer and in Tilapia pond culture. The sooner a fish grows to an economic size for the market, the more money there is for the venture, and the greater cropping rate in a sheet of water. The amount of food in an acre of water, whether natural or artificial can have two effects: either a faster growth rate or a faster reproduction rate. One makes a big individual fish, and the other increases the number of mouths to eat the food. If you double the amount of food by artificial feeding, you may double the growth rate or double the reproduction rate. There are other factors which come into consideration, but very little is known, and many are most puzzling.

Suppose we consider the various natural lakes, beginning with Lake Rudolf and Lake Baringo, which both have one Tilapia: *T. nilotica*. Lake Rudolf is a large lake, covering 6,845 sq. miles of land and a strange thing about it is that there is no aquatic vegetation. The pH is well over 10. The Tilapia in this lake grow to 12 lb. in individual weight. Lake Baringo is a small lake, 62.5 sq. miles in area and there are vast quantities of blue-green algae (Microcystis). The pH is 8.2 to 8.5. The average weight of the Tilapia is 9 ounces. It is interesting to note that there are predatory fish in Lake Rudolf, but none in Lake Baringo. The crocodile does not cause this difference, as it is present in both lakes. It may be caused by the fact that in Lake Rudolf there is little food and the predators keep down the stock, so that there are fewer fish which are older and larger. In Lake Baringo we have plenty of food, no predators, and over-reproduction, giving a small individual fish.

Let us take another example. In the Athi River *T. nigra* has to contend with predatory fish, and grows to an average size of one pound, with plenty of 2 lb. fish. Take *T. nigra* from the Athi River and stock a 4-acre dam, with no predators, and in two years the average size of fish will be two ounces. There is some other factor which, despite the presence of a predator, gives a large individual fish.

As over-reproduction produces runts, this matter is of great importance when the policy is to stock all artificial sheets of water with Tilapia. There are a number of ways by which this problem can be tackled. Number one is by the introduction of a predator: this may work in large dams but the great danger is that in small dams the predator will eat out the Tilapia and then eat out themselves. This actually happened in a test pond. At present the proper stocking rate for an acre of water is not known, as so far all stocking has been based on European practice; but work is being done on this fundamental factor. Number two suggestion is to stock one sex only, as it has been found that in small dams a Tilapia which grows to one or two pounds in its natural environment in two to three years, will begin to spawn at 4 in. in length. At this length the age of the fish is four months, so the growth rate was one inch per month. At four months the fish spawns, and spawning takes place approximately every three months or less after that; but the growth rate has fallen to one-fifth of the previous growth rate. The signs are that early spawning cuts down the growth rate, due to bodily exhaustion. We do not know the cause of early spawning, but it is not temperature, nor pH factors, which are generally blamed. Perhaps if one stocks with one sex only, sexual stimulation and breeding will not occur, so that the growth curve should not flatten out, but be a continuous rising curve. Only time will tell if this is correct.

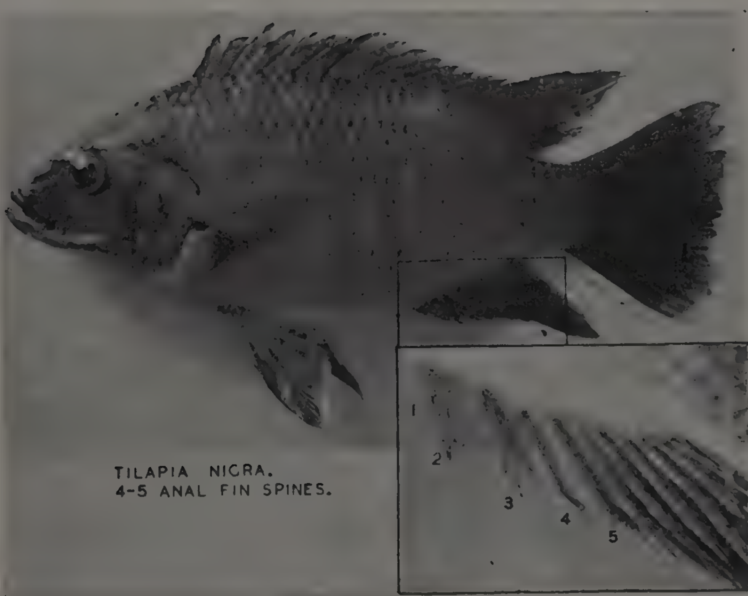
The availability of proteins in the total amount of food is being studied, and so is the factor known to the German workers as "Lebensraum". Put very simply this means that, every fish must have a certain cubic area in which to reach its best age/growth rate. This area differs for each species of fish, and may alter in a strict ratio to the food available.

Thirdly, if spawning in a small confined area cuts down drastically the growth length and weight of the fish, why not produce sterile fish by cross-breeding between separate species? What is needed is to stock a definite weight of fish, bring them up to an economic weight, and eat them. Offspring are not required, as the sterile fish for stocking are raised elsewhere. This is attractive, and only time will show if the Tilapia will co-operate.

The Economic Value of Tilapia

In view of their excellent food value, Tilapia of all sorts have been caught by native fishermen from time immemorial, but it was not until the introduction of the 5-in. gill net by a Norwegian named Aarup, in 1905, that an organized fishery was started in Lake Victoria. (Aarup also made the first sailing fishing craft; these are 25 ft. long, 6 ft. beam, and 2 ft. 6 in. deep.) The ups and downs of the fishery can be studied in the "Review of Kenya Fisheries" for 1948 and 1949 and its extent and importance in the Kenya waters of Lake Victoria can be judged from the fact that in 1951 2,400.000 Tilapia, of an approximate weight of 3,000,000 lb., were exported from Kisumu during the year. Their value to the fishermen was £82,500, and the retail value £127,500, and does not include native or local consumption. It has been calculated that 12,000 tons of Tilapia are caught in Lake Victoria every year, and this figure is rising as the measures for distribution improve. Every night of the year 8,000 gill nets are set in the Kavirondo Gulf. The longest life of these nets is from 6 weeks to 2 months; so it will be understood that importing and selling nets to the fishermen of Lake Victoria is quite a big business.

TILAPIA MELANOPLEURA.
3 ANAL FIN SPINES.



TILAPIA NIGRA.
4-5 ANAL FIN SPINES.

Lake Rudolf is undeveloped owing to its remoteness from a market, bad roads, and small lakeside population, but the time is rapidly approaching when this will change. A small quantity of fish is now caught and shipped as sun-dried fish (the present catch is in the region of 250,000 per year); but what is really wanted is preliminary survey work on catch rates, migrations, best methods of fishing, etc. As I said above, Lake Rudolf has predators in the form of Tiger fish and Nile Perch. The Tiger fish is economically useless but the Nile Perch is valuable; so that the final fishery will be based on the Tilapia and the Nile Perch.

The Athi and the Tana Rivers are fished hard by the indigenous races and the same can be said for Lake Jilore and Lake Jipe; but the catch is small.

Since the war a lot of attention has been given to the breeding of fish in large fish farms and dams, based on work already done on the Continent and in Palestine with the various kinds of European Carp. In the United States of America great attention has been paid to the farm dam and a mass of literature has been poured out on the subject. The success of the farm dam in the United States is by no means certain, and many snags have got to be smoothed out before final success is attained. This enthusiasm spread to East Africa after the war; but the fact is that it is not possible to put fish into a farm dam, either European or Native, and then just sit back in anticipation of one's fish dinners.

There are two fundamental points to start from. Except for about two favourable places where the land is good and water is available without pumping, there is no place for the commercial fish farm run on a business basis in Kenya. The second fundamental fact is that the water in a farm dam is far more valuable than the fish, so that any scheme of raising fish which entails in its operation the draining of the farm pond is out of the question.

For 15 years dams in Kenya have been stocked with *T. nigra*. Experiments were made with American Bluegill (*Lepomis macrochirus*) with disappointing results, and all work with this fish has been abandoned. Experiments with a Tilapia-Black Bass combination have been made, and there is no doubt that in certain sections of the Colony this combination works well and will be extended.

Farm ponds are being built on a large scale every year, and it is an economic necessity that they shall also provide some fish food. It is foolish to talk about raising from 1,000 to 2,000 lb. of fish per acre, each fish being of an economic selling size, for it cannot be done by any system now known to us; but it is possible to raise from 400 to 500 lb. of fish of an economic selling size per acre per year.

Relationship of Tilapia to Disease Control

As the farm dam must do its share in raising fish for food, the question arises as to whether Tilapia could help in the control of disease, especially malaria and bilharzia.

T. melanopleura was introduced into the Colony because it was a weed eater, and being so it would help in the eradication of both malaria and bilharzia: if a dam is clear of emergent weed, there is a ripple of waves across the water surface which is deterrent to the mosquito larvae, also by clearing out weed one cuts down considerably the habitat of the snail which carries bilharzia. Besides doing all this, *T. melanopleura* is a good eating fish, but it must be remembered that *T. melanopleura* will only eat weeds when it has attained a length of 5 in. to 6 in. or more. The introduction of the tiny mosquito-eating fish, gambusia, into the very shallow fringing edges of the dam, is also a help. The clearing of emergent and underwater weed also helps very considerably, by increasing sunlight in the dam. This will increase phytoplankton in the dam, which could be utilized by *T. nigra*.

The dam of the near future may be stocked with *T. melanopleura* to keep weeds down; *T. nigra* to utilize the extra phytoplankton; and gambusia in the fringing edges of the pond. Time may prove that the introduction of a predator is necessary. In certain areas the Black Bass might be used, whilst in others Clarias might perform the same functions. For farm ponds in the coastal areas the combination might prove to be *T. mossambica* as a food fish, and a predator such as Clarias.

The Tilapias of Kenya have been described with the idea of utilizing them in farm ponds to help the food supply of the Colony. Ideas have been put forward and discussed on various problems that have arisen, the most important being "runting". It only remains to say that work is being carried out on these problems at the Fish Culture Farm and there is no doubt that in the near future many will be solved.

Finally, I am most grateful to Dr. van Someren for the photographs illustrating the article.

THE EFFECT OF TRYPANOSOMA RHODESIENSE ON TEMPERATURES OF SHEEP

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Literature

I have given (1950) an account of factors which may influence body temperature in warm-blooded animals. In the majority this does not remain quite constant throughout the 24 hours; it rises somewhat during the day, because heat is not lost as rapidly as it is generated or acquired from the environment. In healthy individuals this superfluous heat is lost during the night and the body temperature drops to a level which is characteristic for the individual, race, or species concerned. In the same species the level of stability of temperature may vary with season, or with the part of the world in which the animal is living. Average figures have to be based on the study of many individuals and as large a number of observations as possible. Overcrowding at night may impede heat loss, in which case the body temperature in the early morning may still be considerably higher than is normal for the species concerned.

With regard to records of early morning rectal temperatures in sheep, Ironside (1943) and Boddie (1944) give the range for sheep in Great Britain as from 102° F. to 104.2° F. Starling gives 104° F. for sheep in Europe (Evans and Hartridge, 1933), Minnet and Sen (1945) record figures from India of 101.54° F. in the cold and 103.87° F. in the hot season. Quinlan and Maré (1932) in January in the Karoo found temperatures in sheep between 101° F. and 102° F. Vanderplank (1941) gave the figure for healthy sheep at Tinde, Tanganyika Territory as 103.4° F. This mean was based on 150 observations on four animals. For goats he gave 102.8° F. based on 100 observations on two animals. In 1942 he added that the temperature readings were taken before 7 a.m. Hornby (1952) thought these figures were not typical for these two species in Tanganyika. On experience from the Veterinary Laboratory, Mpwapwa, he thought the mean expected early morning rectal temperature of healthy adult sheep should be about 102° F. and of goats 101.5° F. He went on to write that in either species the actual reading may be anything between 100° F. and 103° F.; many more observations than were made by Vanderplank were needed before comparative figures could be obtained which could be accepted.

The Investigation

Sheep have been used in connexion with sleeping sickness research at Tinde for many years (Fairbairn and Burtt, 1946) and Corson (1931) demonstrated the presence of trypanosomes in the cerebro-spinal fluid in both sheep and goats infected with the fatal *Trypanosoma rhodesiense*. Since there seemed to be doubt as to the correct figure for the early morning rectal temperature of these animals I recorded observations on healthy individuals of both species and on sheep infected with *T. rhodesiense*. The results form the subject of this paper.

(*a*) *Situation and Climate of Tinde*

Tinde is situated in lat. 3° 52′ South and long. 33° 12′ East, 26 miles south-west of Old Shinyanga, in the western part of the Central Plateau of Tanganyika. The altitude is between 3,800 and 3,900 feet. The climates of Tinde and Old Shinyanga are very much alike and similarly influenced by the presence of Lake Victoria to the north. The rains usually break in November and tail off in May; typically there is a dry spell lasting about a month from late January into February. During the first part of the dry season (June, July), the early mornings are cool and fresh. Air temperatures reach their minimum in July and then rise to their maximum in October, or until the rains break. The time of sunrise at Tinde varies only about half an hour throughout the year, being earliest in November (6.23 a.m.) and latest in February and July (6.53 a.m.). (Data kindly supplied by the East African Meteorological Service.)

(*b*) *Period of Observation and Technique*

Observations on sheep temperatures were made from July, 1942 until May, 1944. Healthy goats were studied only for about a month from mid-March, 1944. Two skilled African assistants using half-minute clinical thermometers started observations at 7.30 a.m.

(E.A.S.T.) and temperatures were sometimes retaken as a check. No records of the outside air shade temperature or saturation deficit were kept at Tinde.

(c) *The Animals*

Male sheep were used, most of them over one year old. They belonged to the haired, small, fat-tailed race—distinct from the Masai and Persian races, as described by French (1938).

Healthy and *T. rhodesiense* infected sheep were herded and housed together; until August, 1943, they were kept in a thatched mud-brick house with a cement floor, situated about 150 yards from the laboratory to which they were walked before their temperatures were taken. Subsequently they were kept in a cement house with a corrugated iron roof, in front of which was a wire netting pen 20 yards long shaded by *Cassia siamea* trees and temperatures were taken in this pen. Care was always taken not to overcrowd the sheep, at least one square yard of floor space being available to each individual; adequate drinking water was supplied and their quarters were cleaned out daily. Until March, 1943, they were bedded down on sand, then straw was substituted, but since this proved unhygienic the sand method was again used from May onwards.

Results

The results for ten healthy and nine *T. rhodesiense* infected sheep are shown in Figure 1. Data for two clean sheep (R and S) are not shown, because the observations covered only April and May, 1944. The mean early morning rectal temperature of these two animals was 102.1° F.

The means with their standard error are shown in Table I. The results for healthy goats are also shown.

The mean sheep temperatures showed no correlation from season to season with the mean shade air temperature or saturation deficit as recorded at 8 a.m. at Old Shinyanga.

Comments

The results obtained from the healthy animals conform closely with the figures given by Hornby (loc. cit.). The single figure of 104° F. given by Starling is not generally accepted as representative of sheep in Europe a great many have lower mean temperatures. The figures quoted by Boddie and Ironside are more truly representative of the species.

Figure 1 shows that sheep C tended to run a higher temperature than the others. This seems to be an example of individual difference. Its blood was frequently examined in stained thick films and no trypanosomes were found until June, 1943.

Animals E to K (Fig. 1) were infected by the application of boxes of flies previously fed on an infected sheep. It can be seen that febrile symptoms developed in F, G and H before the presence of trypanosomes could be detected on slides.

Sheep A, B and C were not infected experimentally, since, as with D, it was intended to study them in a healthy condition for a full year. All three were accidentally infected with *T. rhodesiense*—possibly the infection was conveyed to them mechanically from other infected animals by fleas, which were swarming on the bedding straw, and for that reason bedding down with straw was discontinued. Such accidental infections have never occurred in any other animal at Tinde. Attempts to demonstrate the possibility of mechanical infection by fleas from infected rats to healthy rats were unsuccessful. The early morning rectal temperatures for sheep and goats recorded by Vanderplank (1941) were

Table 1.—Mean Early Morning Rectal Temperatures of Healthy and Infected Sheep and Healthy Goats at Tinde

Species	Mean early morning rectal temperature (°F.) and its standard error	Number of observations	Number of animals studied
Sheep (A)	102·08 ± 0·01	2,173	12
Goat	101·25 ± 0·02	301	7
Infected Sheep (B)	102·9 ± 0·1	378	9

(B) is significantly higher than (A), P<01.

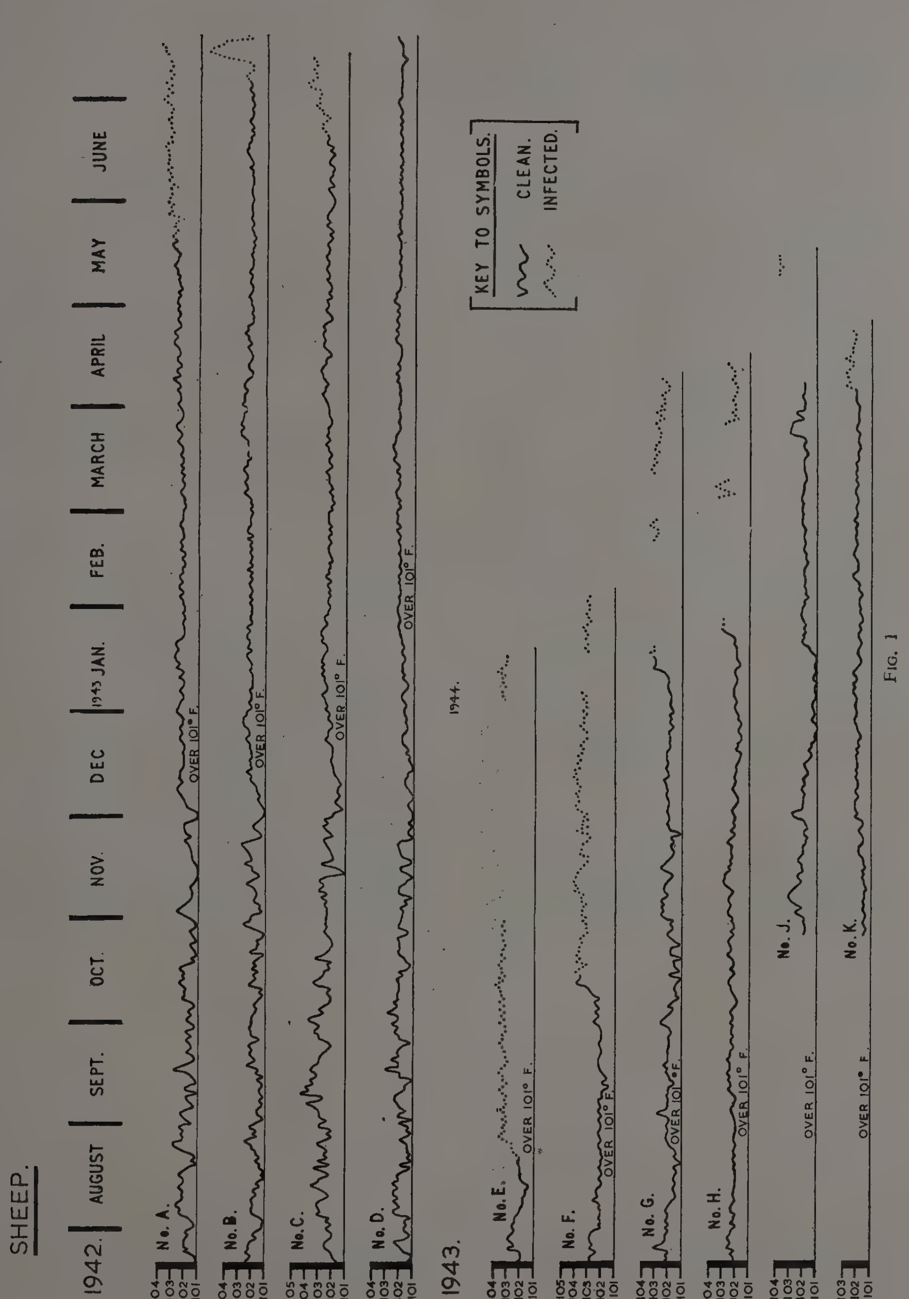
SHEEP.
1942.
AUGUST
SEPT.
OCT.
NOV.
DEC
1943 JAN.
FEB.
MARCH
APRIL
MAY
JUNE
No. A.
No. B.
No. C.
No. D.
OVER 101° F.
1943.
1944.
No. E.
No. F.
No. G.
No. H.
No. J.
No. K.
KEY TO SYMBOLS.
CLEAN.
INFECTED.

FIG. 1

too high to be characteristic of healthy animals and as temperatures of 104° F. were frequently observed in the afternoon and early evening, the high temperatures he found were probably due to his animals being overcrowded at night.

Summary

The mean early morning rectal temperature of healthy sheep studied at Tinde was 102.8° F. with a Standard Error of $\pm$ 0.01° F. (based on 2,173 observations on 12 healthy animals). Seven healthy goats were similarly studied for about one month and the mean temperature was 101.25° F. with a Standard Error of $\pm$0.02° F. Both results conform closely with the figures for healthy individuals of the two species given by Hornby (1942). Sheep infected with *T. rhodesiense* had a mean early morning rectal temperature of 102.9° F. (based on 378 observations with nine animals). The temperature sometimes rose during the incubation period and before trypanosomes could be detected in 200 fields of stained thick blood film. There was no correlation between sheep temperatures and seasonal changes of temperature as measured at Old Shinyanga.

Three sheep were accidentally infected with *T. rhodesiense* possibly mechanically transmitted by fleas. Such accidental infections have never occurred in other animals at Tinde and attempts to demonstrate the ability of fleas to transmit the infection from infected to healthy rats were unsuccessful.

Acknowledgments

I wish to thank Mr. W. H. Potts for granting access to the climatic records at Old Shinyanga and Dr. C. H. N. Jackson for very kindly carrying out the statistical examinations connected with this work.

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PRELIMINARY NOTICE OF THE OCCURRENCE IN KENYA OF A RUST (PUCCINIA POLYSORA) ON MAIZE

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During 1950 and 1951 serious epidemics of rust on maize were reported from West Africa. It was found that these outbreaks were not caused by the common, almost cosmopolitan, rust *Puccinia sorghi*, which is not known to cause serious loss, but by a species until then known only in the warmer parts of America. This rust, *Puccinia polysora*, does not apparently cause severe damage in the countries where it is endemic but on reaching West Africa it gave rise to outbreaks far exceeding in severity those caused by the common maize rust.

Warnings were received late in 1951 of the possible danger of *Puccinia polysora* reaching East Africa. In early July, 1952, it is clear from reports and the examination of material sent to the Scott Laboratory from the Coast Province of Kenya that these fears have been realized. Of the collections recently received from the Mombasa and Taveta districts all have been *Puccinia polysora*.

The common rust *Puccinia sorghi* is found on plants from an early stage. The sori are frequently scattered or, if in groups, these usually occupy a comparatively small area of leaf. The sori themselves are generally elongated or oval and the uredo spores when exposed in the opening sori or in mass liberated on the leaf surface, have a reddish brown colour. The leaf usually retains its normal green colour. *Puccinia polysora*, on the other hand, develops with greater destructiveness. Its major intensity occurs as the maize plants approach maturity. The sori are smaller, usually more closely crowded and generally round. The opened sori and the liberated spores have a golden brown rather than a reddish brown colour. On the sheath the sori are longer and narrower, conforming to the area between the sheath ribs. The area of the leaf involved, the crowded sori and the profusion of the liberated spores give the plants where the attack is severe a "rusted" appearance clearly visible from a distance.

In spite of the generally more striking appearance of *P. polysora*, it may be difficult to distinguish the two rusts in the uredo stage without critical examination, but the teleuto stage is quite distinct. In *P. sorghi*, the sori are comparatively large, elongated and open and of a bright dark brown to black colour. Those of *P. polysora* are smaller, more closely crowded and covered by the unbroken epidermis. The colour is a dull leaden black.

Should this disease become general and develop the virulence which it has shown in West Africa, where losses of up to 70 per cent have been reported, the serious consequences to East Africa need no emphasis. The object of this note is to draw attention to this new disease and to invite Agricultural Officers and others to report suspected outbreaks.

Fig. 1.—"Puccinia Polysora": crowded uredo-sori on upper leaf surface.

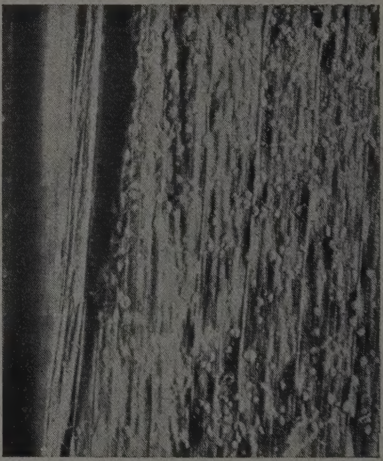

Fig 2.—"Puccinia Polysora": early attack showing small round uredo-sori.

Fig. 3.—"Puccinia Sorghi": Scattered uredo-sori on upper leaf surface.

Fig. 4.—"Puccinia Sorghi: large open teleuto-sori.

(The teleuto-sori of *P. polysori* are barely visible to the unaided eye and are not illustrated.)